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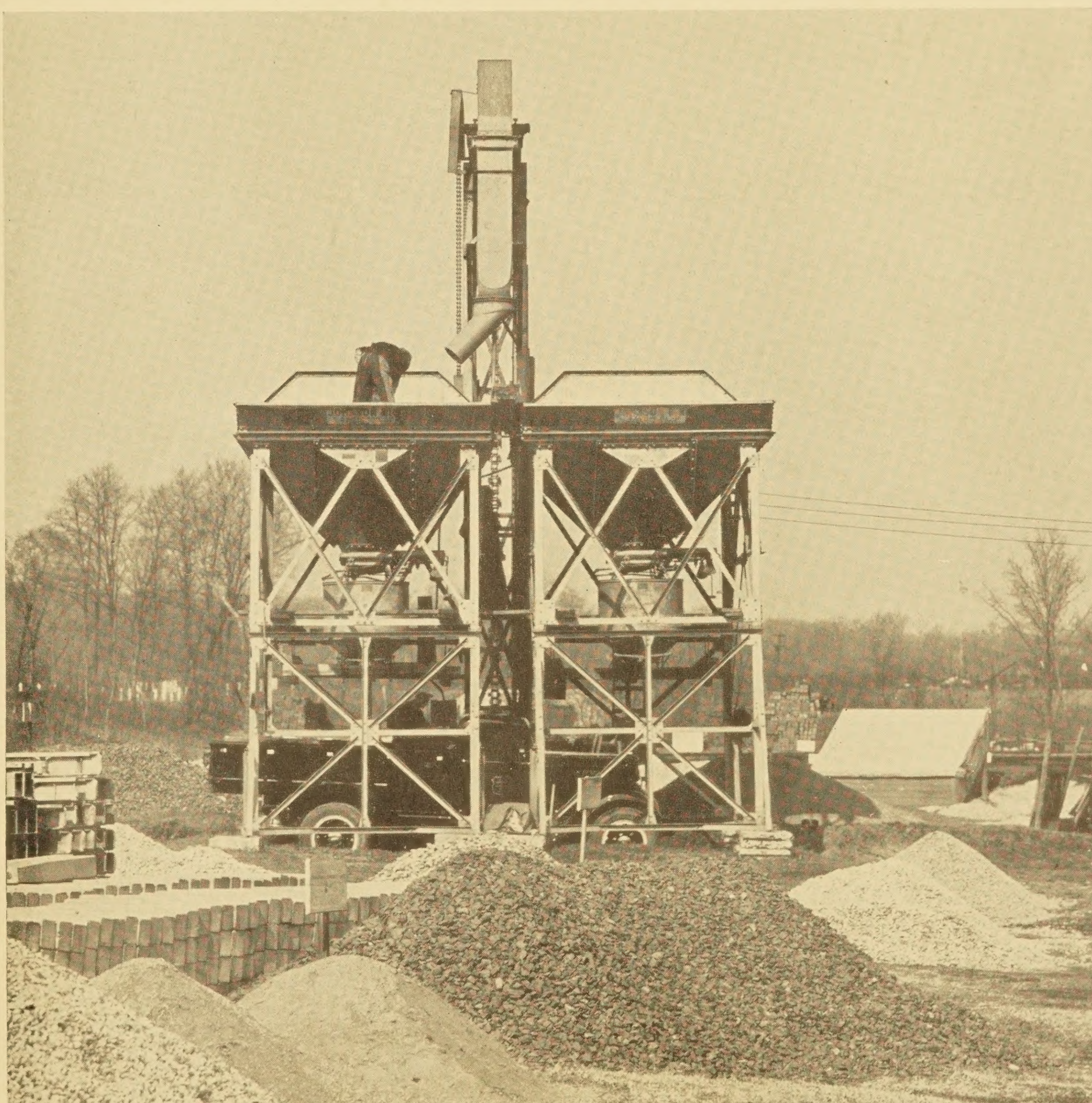

BINS USED IN PROPORTIONING AGGREGATE FOR CONCRETE TEST SECTIONS

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PUBLIC ROADS ▸▸▸ *A Journal of Highway Research*

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The reports of research published in this magazine are necessarily qualified by the conditions of the tests from which the data are obtained. Whenever it is deemed possible to do so, generalizations are drawn from the results of the tests; and, unless this is done, the conclusions formulated must be considered as specifically pertinent only to described conditions

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THE EFFECT OF VIBRATION ON THE STRENGTH AND UNIFORMITY OF PAVEMENT CONCRETE

BY THE DIVISION OF TESTS, BUREAU OF PUBLIC ROADS [1]

Reported by F. H. JACKSON, Senior Engineer of Tests, and W. F. KELLERMANN, Associate Materials Engineer

IN THIS INVESTIGATION the effects of surface vibration on pavement concrete were measured by comparing the strength and other properties of vibrated concrete with similar properties of a standard-finished base mix containing 6 sacks of cement per cubic yard of concrete and sufficient water to produce a slump of 2½ inches. Two types of coarse aggregates—a typical river gravel and a typical limestone—and several forms of surface vibrating equipment were used, including vibrating screeds and vibrating pans resting directly on the concrete.

In the vibrated concrete the proportions of the base mix were varied for the purpose of determining: (1) The saving in cost that might be possible through a reduction in cement content while maintaining the water-cement ratio constant; and (2) the improvement in quality that could be effected by reducing the water-cement ratio while maintaining the cement content constant.

The possibility of using high frequency vibration as an aid in placing pavement concrete was first investigated by the Bureau of Public Roads in 1931. The equipment used at that time consisted of a standard, double-screed finishing machine, with two electric vibrators mounted on the front screed and one on the rear screed. An experimental concrete pavement, 9 feet wide and approximately 1,000 feet long, was constructed at Arlington, Va. This pavement consisted of a series of sections, each 9 feet long, with means provided for obtaining large-size test slabs from each section. It was felt that the true effect of this method of placing and finishing concrete pavements could only be determined by the construction of full-size sections, using regulation contractors' equipment. The results of these studies, including a full description of the procedure, have been published.[2]

CONCLUSIONS DRAWN FROM TEST RESULTS

The data from these tests indicate that:

1. For a given water-cement ratio a saving of approximately 10 percent in the amount of cement can be effected by the use of vibration without sacrificing strength and uniformity.

2. For a given cement content an increase in flexural and compressive strength of approximately 10 percent can be obtained by the use of vibration.

3. With the methods of surface vibration investigated the best results will be obtained with concrete having a consistency corresponding to a slump of approximately 1 inch.

4. The uniformity of concrete having a slump of approximately 1 inch (that is, freedom from segregation, honeycombed areas, etc.) is markedly improved by surface vibration.

5. The effect of surface vibration on strength and uniformity seems to be about the same for concrete containing gravel as coarse aggregate as for concrete containing crushed stone.

6. The vibrating screed and the vibrating pan mounted independently of the screeds seem to be about equally effective in producing the results enumerated in the above conclusions.

These tests indicated that vibration caused sufficient improvement in quality to warrant further studies in which improved types of vibratory equipment could be utilized. The present report discusses the results of these further tests, draws certain conclusions, and makes suggestions regarding the revision of current specifications so as to make it possible to utilize to the best advantage the equipment now available. The data also reveal some of the deficiencies in the present methods of distributing concrete to the subgrade. Entirely apart from the question of vibration, the results indicate the great desirability of improvement in this regard.

Results of tests on 270 sections, each 8 feet long and 10 feet wide, are presented and discussed in this report. These test sections formed the equivalent of a continuous pavement nearly ½ mile long. In most cases the thickness was the same as that previously used (7 inches). However, slabs 10 inches thick were cast in a few instances for purposes of comparison. The width was changed from the 9 feet previously used to 10 feet in order to permit taking 5 slabs each 24 inches wide from each test section instead of 4 slabs each 27 inches wide. Two coarse aggregates, a typical river gravel and a typical crushed stone, were used. Four different types of vibrating equipment, including all of the types commercially available at the time, were investigated, using paving mixtures varying considerably in harshness and consistency. The construction, curing, and test procedures followed, in general, those previously employed and will not be described in detail, except where necessary to describe a change from previous practice.

FOUR TYPES OF VIBRATING EQUIPMENT STUDIED

A single lot of portland cement meeting the usual requirements was used throughout the work. The cement came from one bin and was all shipped at one time. The shipment was made under the supervision of an inspector representing the National Bureau of Standards. The fine aggregate was Potomac River sand having a fineness modulus of approximately 3.0.

[1] Acknowledgment is made to the following companies, which loaned equipment used in these tests:
Jaeger Machine Co., Columbus, Ohio.
Blaw-Knox Co., Pittsburgh, Pa.
Baily Vibrator Co., Philadelphia, Pa.

[2] The Effect of Vibration and Delayed Finishing on Pavement Slabs, by F. H. Jackson and W. F. Kellermann. PUBLIC ROADS, vol. 14, no. 8, October 1933.

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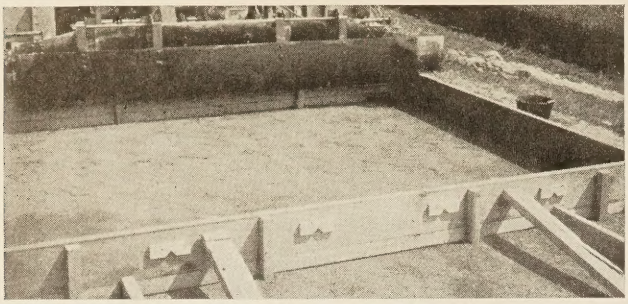
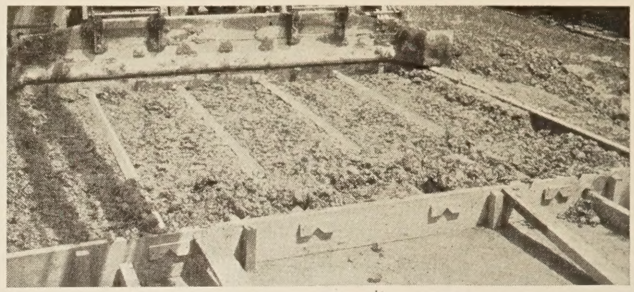


Forms in Place and Subgrade Prepared, Ready for Concrete To Be Deposited for a 10-Inch Test Section.



Appearance of a 7-Inch Test Section After First Batch of Concrete Has Been Struck Off and After Installation of Wooden Separators.

The coarse aggregates were Potomac River gravel and a crushed stone from Riverton, Virginia. They were used in approximately equal amounts and were handled in two separated sizes, 2-inch to 1-inch, and 1-inch to No. 4. The two sizes were combined in each batch in the proportion of 60 percent of the larger to 40 percent of the smaller size. The grading and physical characteristics of the aggregates are shown in table 1.

The major portion of the work was confined to a study of two well-known mechanical finishing machines, equipped in each case to operate either with or without vibration. Machine A, used on 144 sections, was of the type studied in the 1931 tests, except that a wider and heavier front screed was used. The type of finisher represented by machine B, used on 106 sections, had not been equipped with a vibrating mechanism at the time the earlier tests were run. Two other devices submitted for demonstration purposes were used on the remaining 20 sections. A brief description of each machine follows.

Table 1.—*Properties of aggregates used in experimental concrete sections*

	Fine aggregate	Coarse aggregate	
		Gravel	Crushed stone
PHYSICAL PROPERTIES			
Bulk specific gravity	2.56	2.57	2.76
Absorption ... percent	1.40	1.14	.32
Weight per cubic foot (dry-rodded) ... pounds	110	109	103
Voids ... percent	31	32	40
Wear (Deval) ... do	-------	8.4	3.4
SIEVE ANALYSES			
Retained on—			
1½-inch sieve ... percent	-------	25	18
¾-inch sieve ... do	-------	64	71
⅜-inch sieve ... do	-------	87	92
No. 4 sieve ... do	5	98	99
No. 8 sieve ... do	22	100	100
No. 14 sieve ... do	34	100	100
No. 28 sieve ... do	51	100	100
No. 48 sieve ... do	84	100	100
No. 100 sieve ... do	97	100	100
Fineness modulus	2.93	7.74	7.80

Machine A was a mechanical finishing machine equipped with two tilting screeds. Power for operating the screeds and for driving the machine was furnished by a gasoline engine mounted on the finisher. The regular front screed was replaced by an 18-inch bull-nose screed. Two electric vibrators were mounted on the front screed and one on the rear screed. They were driven at a speed of 4,000 r. p. m. by a portable gas-electric generator set mounted on the finisher. The normal forward speed of the machine was 8 feet per minute.

Except for the fact that the screeds were vibrated, this machine was operated in most cases in the usual way, that is, two complete passes over the concrete.

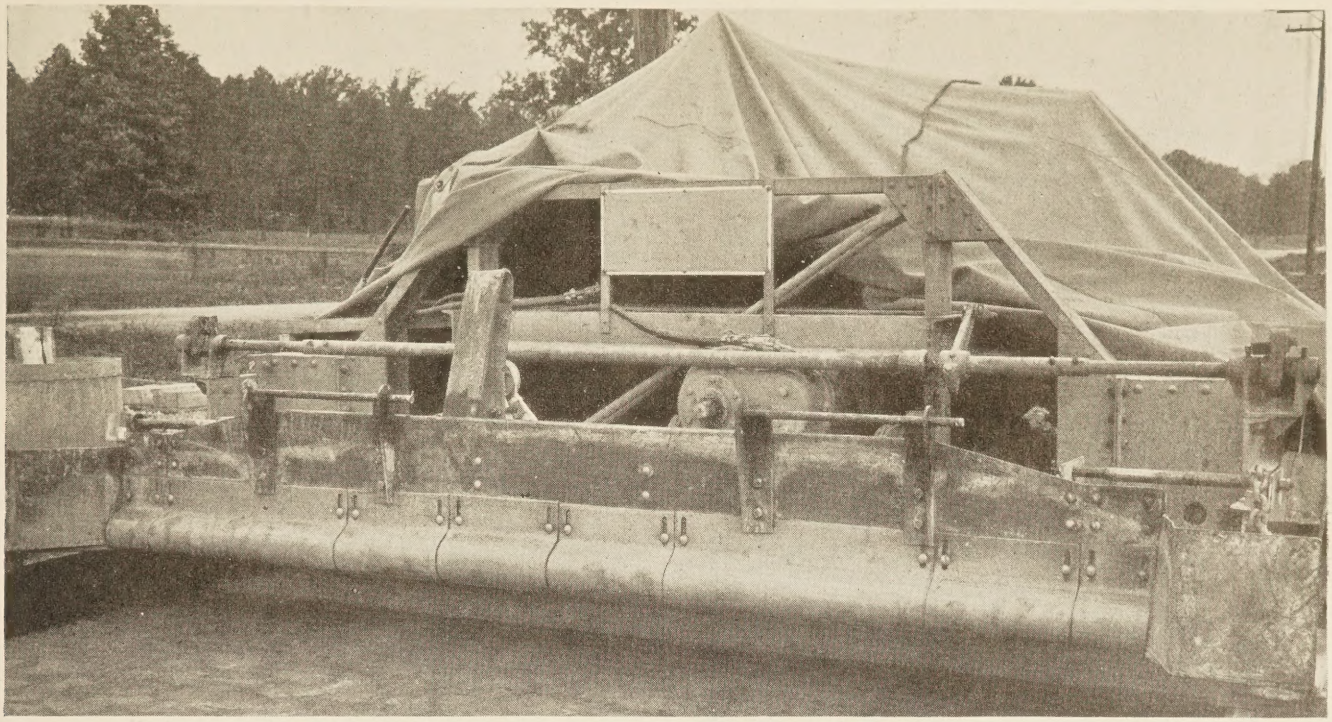
Machine B was an all-electric mechanical finishing machine equipped with two screeds and a vibrating pan mounted between them. The vibrating pan was shaped like a trough and made contact with the concrete for practically the full width of the pavement. It was adjustable so that it could be raised clear of the concrete or could be lowered into the concrete a predetermined depth. It was equipped with two electric vibrators of adjustable amplitude operating at 3,600 r. p. m. There were no vibrators on the screeds. Power for running the machine, operating the screeds, and running the vibrators was supplied by a gas-electric unit mounted on the finisher.

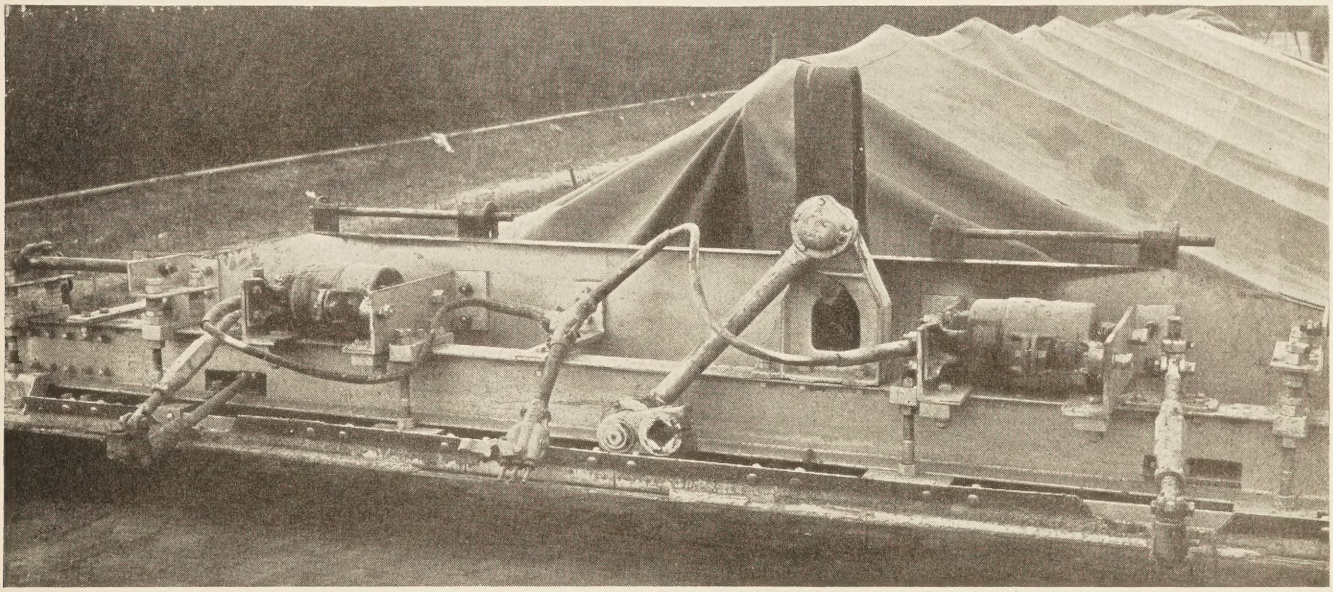
The concrete was struck off approximately one-fourth inch high by the front screed and compacted with the vibrator. The vibrating pan was submerged in the concrete to the extent that its lower edge was about one-fourth inch below the elevation of the top of the side forms. In most cases the vibrator was operated during the backward pass of the finisher as well as during the forward pass. By running the vibrator during the backward pass, a ridge of mortar was left at the beginning of the section which materially aided in the finishing operations. The height above the forms to which the concrete was struck varied with the consistency and harshness of the mix. The objective sought was to have sufficient surplus concrete so that, after vibrating, the surface would be at grade. For the second and subsequent passes the machine was operated in the usual way without vibration.

Machine C was not a regular finishing machine but rather a single, hand-operated screed with two vibrators attached. It consisted of a 4-inch wooden plank 15 inches wide, shod with sheet steel, and approximately 12 feet long. Handles were provided at both ends for manipulation. This device was vibrated at a frequency of 3,800 r. p. m. by means of a small gasoline engine attached to the screed.

The concrete was leveled off about 2 inches high by shovels and a pass made with the vibratory screed, the screed being pushed ahead by finishing machine A. The vibrating screed was moved ahead and the pavement finished by machine A except that the bull-nose front screed was replaced by the regular 12-inch screed. The 12-inch screed weighed approximately 450 pounds less than the bull-nose screed with vibrators.

Machine D consisted of a two-wheel steel carriage, to which was attached a steel trough 12 inches wide, mounted at right angles to the axis of the pavement. The trough could be lowered into the concrete a pre-





Bull-Nose Front Screed on Finishing Machine A. Upper, Front View; Lower, Rear View.

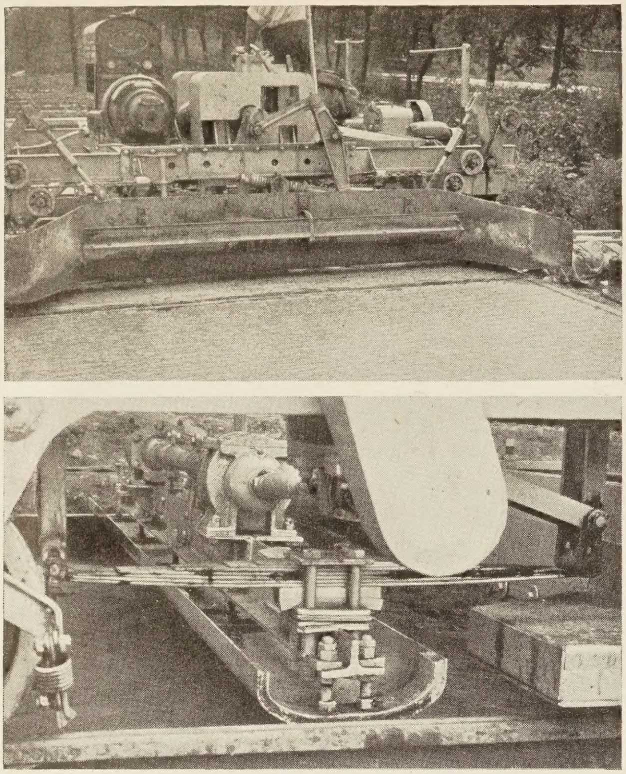
determined depth in a manner similar to the operation of the vibrator on machine B. Vibrations were imparted to the trough by means of a 3¼-inch steel tube revolving at a speed of approximately 3,800 r.p.m. The tube was mounted eccentrically on a shaft which was attached directly to the trough by suitable bearings. The eccentricity of the tube could be varied, resulting in varying amplitude of vibration. Power was supplied directly to the shaft from a gasoline engine mounted on the carriage through a V-belt drive. The machine was attached to the rear of finishing machine A.

The concrete was struck off approximately three-fourths inch high by machine A operating with a flat front screed. This was followed by one pass with the vibrating pan, the general procedure being the same as with machine B except that in no case was the vibrator operated on the backward pass. The final finish was obtained by making one or two passes with finishing machine A without vibration.

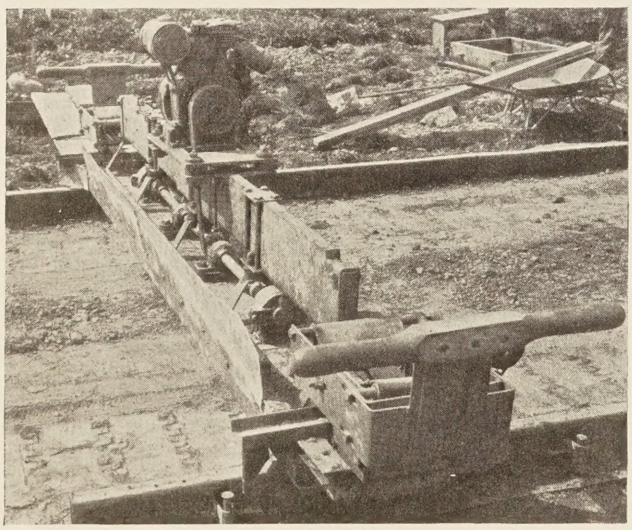
Table 2 shows the order in which the vibrators were used as well as the procedure followed for each group of sections. It will be observed that only machine A was used in series A. Machines A and B were used in series B, and machines C and D were used in series C.

SEVERAL DIFFERENT CONCRETE MIXES USED IN SLABS

As in the previous tests, the effect of vibration was measured by comparing the strength and other properties of the vibrated concrete with similar properties of a standard-finished paving mix having a cement content of 6 sacks per cubic yard, and containing suffi-



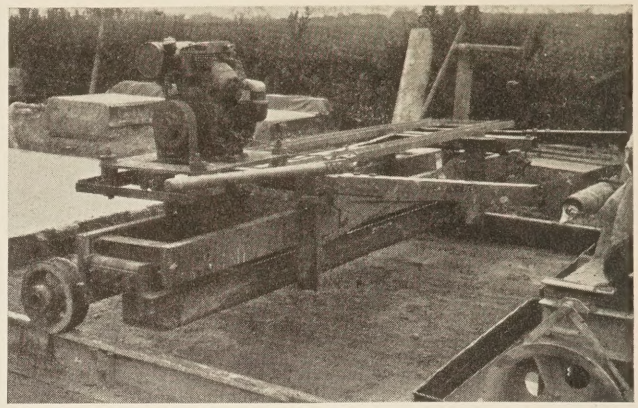
Finishing Machine B. Upper, Front View; Lower, Side View, Showing Mounting of Vibrating Pan.



Finishing Machine C—A Hand-Operated Screed Vibrated by Means of the Small Gasoline Engine Shown.

cient water to give a slump of about 2½ inches. In the following discussion this will be referred to as the standard or "base" mix.

For the first 42 sections, constituting series A, the proportions of the base mix were designed to give a workability factor (b/b_0) of approximately 0.76 (dry and rodded) for both gravel and stone. Corresponding values for the sand-cement ratios (a/c) by absolute volume were 2.10 for gravel and 2.53 for stone. This mix proved somewhat harsh for standard finishing, necessitating a slight increase in the amount of sand. The revised proportions for the base mix as used in



Finishing Machine D, Showing the Pan Vibrator.

series B and C called for a workability factor of 0.73, with sand-cement ratios of 2.24 for gravel and 2.67 for stone. (Explanations of symbols b/b_0, a/c, etc., are given in the footnote to table 3.)

Table 2.—*Type and operation of vibrating equipment*

Section no.	Figures in which data are shown	Coarse aggregate	Operation of finishing machine
SERIES A—MACHINE A			
1–6	12	Gravel	Both screeds vibrating; 2 passes.
7–12		do	Front screed only vibrating; 2 passes.
13–18		do	Do.
19–24	12	do	Both screeds vibrating; 2 passes.
25–30	12	do	Do.
31–36	12	Stone	Do.
37–42	12	do	Do.
SERIES B—MACHINE A			
43–49	6–11, inclusive	Stone	Both screeds vibrating; 2 passes.
50–56	do	do	Do.
57–63	do	Gravel	Do.
64–70	do	do	Do.
177–182	6–13, inclusive	Stone	Do.
183–189	6–11, inclusive	Gravel	Do.
190–196	do	do	Do.
197–202	6–12, inclusive	do	Do.
203–208 [1]	6–9, inclusive	do	Do.
209–214	6–12, inclusive	do	Do.
215–220		do	Front screed only vibrating; 2 passes.
221–226	6–11, inclusive	do	Both screeds vibrating; 2 passes.
227–232	6–13, inclusive	Stone	Do.
233–238		do	Front screed only vibrating; 2 passes.
239–244	6–11, inclusive	do	Both screeds vibrating; 2 passes.
245–250 [1]	6–9, inclusive	do	Do.
SERIES B—MACHINE B			
71–76		Gravel	Pan vibrating forward only; 1 pass.
77–82		do	Do.
83–88		do	Do.
89–94		Stone	Do.
95–100 [1]	6–9, inclusive	do	Pan vibrating forward and back.
101–106 [1]	do	Gravel	Do.
107–112	6–11, inclusive	do	Do.
113–119	do	do	Do.
120–126	do	do	Do.
127–132	do	do	Do.
133–138	do	do	Do.
139–144	6–11, inclusive, 13	Stone	Do.
145–150	do	do	Do.
151–156		do	Pan vibrating forward only; 1 pass.
157–162	6–11, inclusive	do	Pan vibrating forward and back.
163–169	do	do	Do.
170–176	do	do	Do.
SERIES C—MACHINES C AND D			
251–254	13	Stone	Machine C, 1 pass.
255–258	13	do	Do.
259–264	13	do	Machine D, 1 pass.
265–270	13	do	Do.

[1] Depth of section was 10 inches.

TABLE 3.—*Data on mixes* [1]

Section no.	Date laid (1934)	Proportions by weight	Coarse aggregate	Slump	W/C	a/c	b/b_0	M/V	Cement factor
		Pounds		*Inches*					*Sacks per cubic yard*
1-S	June 26	94:165:371	Gravel	2.9	0.68	2.10	0.75	2.02	6.0
2-S	do	94:165:371	do	1.6	.62	2.10	.76	1.96	6.1
3-V	do	94:165:371	do	1.6	.61	2.10	.76	1.95	6.1
4-V	do	94:165:425	do	2.2	.68	2.10	.80	1.76	5.6
5-V	do	94:165:452	do	1.8	.68	2.10	.83	1.66	5.4
6-V	do	94:165:480	do	1.5	.68	2.10	.85	1.56	5.2
7-S	June 27	94:165:371	do	3.0	.68	2.10	.75	2.02	6.0
8-S	do	94:165:371	do	1.3	.59	2.10	.77	1.94	6.1
9-V	do	94:165:371	do	1.2	.59	2.10	.77	1.94	6.1
10-V	do	94:165:425	do	2.5	.68	2.10	.80	1.76	5.6
11-V	do	94:165:452	do	2.1	.68	2.10	.83	1.66	5.4
12-V	do	94:165:480	do	1.8	.68	2.10	.85	1.56	5.2
13-S	July 5	94:165:371	do	2.4	.70	2.10	.75	2.04	5.9
14-S	do	94:165:371	do	1.1	.63	2.10	.76	1.97	6.0
15-V	do	94:165:371	do	1.0	.63	2.10	.76	1.97	6.0
16-V	do	94:165:425	do	1.5	.70	2.10	.80	1.78	5.5
17-V	do	94:165:452	do	1.2	.70	2.10	.82	1.67	5.3
18-V	do	94:165:480	do	.8	.70	2.10	.84	1.57	5.2
19-S	July 6	94:165:371	do	2.5	.71	2.10	.75	2.05	5.9
20-S	do	94:165:371	do	1.4	.65	2.10	.76	1.99	6.0
21-V	do	94:165:371	do	1.4	.65	2.10	.76	1.99	6.0
22-V	do	94-165:425	do	1.8	.71	2.10	.80	1.78	5.5
23-V	do	94:165:452	do	1.2	.71	2.10	.82	1.68	5.3
24-V	do	94:165:480	do	.8	.71	2.10	.84	1.58	5.2
25-S	July 9	94:165:371	do	2.2	.68	2.10	.75	2.02	6.0
26-S	do	94:165:371	do	1.2	.62	2.10	.76	1.96	6.1
27-V	do	94:165:371	do	1.4	.62	2.10	.76	1.96	6.1
28-V	do	94:165:425	do	1.5	.68	2.10	.80	1.76	5.6
29-V	do	94:165:452	do	1.2	.68	2.10	.83	1.65	5.4
30-V	do	94:165:480	do	.9	.68	2.10	.85	1.56	5.2
31-S	July 11	94:198:350	Stone	2.7	.73	2.53	.76	1.81	6.0
32-S	do	94:198:350	do	1.4	.69	2.53	.76	1.78	6.1
33-V	do	94:198:350	do	1.4	.69	2.53	.76	1.78	6.1
34-V	do	94:198:402	do	2.1	.74	2.53	.81	1.58	5.6
35-V	do	94:198:428	do	1.4	.74	2.53	.84	1.49	5.4
36-V	do	94:198:453	do	1.2	.74	2.53	.86	1.40	5.3
37-S	July 12	94:198:350	do	2.4	.73	2.53	.76	1.81	6.0
38-S	do	94:198:350	do	1.4	.69	2.53	.76	1.78	6.1
39-V	do	94:198:350	do	1.6	.69	2.53	.76	1.78	6.1
40-V	do	94:198:402	do	1.4	.73	2.53	.81	1.58	5.6
41-V	do	94:198:428	do	1.1	.73	2.53	.84	1.48	5.5
42-V	do	94:198:453	do	.8	.73	2.53	.86	1.40	5.3
43-S	July 19	94:209:340	do	2.4	.77	2.67	.73	1.95	5.9
44-S	do	94:209:340	do	1.0	.71	2.67	.73	1.90	6.0
45-V	do	94:209:340	do	1.0	.71	2.67	.73	1.90	6.0
46-V	do	94:194:360	do	1.4	.73	2.47	.77	1.74	6.0
47-V	do	94:194:360	do	1.0	.70	2.47	.78	1.71	6.0
48-V	do	94:177:378	do	1.2	.73	2.27	.81	1.59	6.0
49-V	do	94:177:378	do	.8	.70	2.27	.82	1.57	6.0
50-S	July 20	94:209:340	do	2.4	.77	2.67	.73	1.95	5.9
51-S	do	94:209:340	do	1.6	.73	2.67	.73	1.92	6.0
52-V	do	94:209:340	do	1.2	.73	2.67	.73	1.92	6.0
53-V	do	94:194:360	do	1.4	.72	2.47	.77	1.73	6.0
54-V	do	94:194:360	do	.8	.68	2.47	.78	1.70	6.0
55-V	do	94:177:378	do	1.6	.73	2.27	.81	1.59	6.0
56-V	do	94:177:378	do	.9	.69	2.27	.82	1.56	6.0
57-S	July 23	94:176:354	Gravel	2.6	.74	2.24	.72	2.24	5.9
58-S	do	94:176:354	do	1.2	.66	2.24	.73	2.16	6.1
59-V	do	94:176:354	do	1.2	.66	2.24	.73	2.16	6.1
60-V	do	94:163:376	do	1.4	.67	2.08	.76	1.98	6.0
61-V	do	94:163:376	do	.9	.64	2.08	.77	1.95	6.0
62-V	do	94:146:392	do	2.0	.67	1.88	.79	1.81	6.0
63-V	do	94:146:392	do	.8	.62	1.88	.80	1.77	6.0
64-S	July 24	94:176:354	do	2.8	.75	2.24	.71	2.25	5.9
65-S	do	94:176:354	do	1.4	.66	2.24	.73	2.16	6.1
66-V	do	94:176:354	do	1.2	.66	2.24	.73	2.16	6.1
67-V	do	94:163:376	do	1.6	.67	2.08	.76	1.98	6.0
68-V	do	94:163:376	do	.9	.64	2.08	.77	1.95	6.0
69-V	do	94:146:392	do	1.5	.65	1.88	.80	1.79	6.0
70-V	do	94:146:392	do	.9	.61	1.88	.81	1.76	6.0
71-S	July 26	94:176:354	do	2.6	.73	2.24	.72	2.23	6.0
72-S	do	94:176:354	do	1.1	.64	2.24	.73	2.14	6.1
73-V	do	94:176:354	do	1.2	.64	2.24	.73	2.14	6.1
74-V	do	94:176:409	do	1.7	.73	2.24	.77	1.93	5.5
75-V	do	94:176:436	do	1.1	.73	2.24	.79	1.81	5.4
76-V	do	94:176:463	do	.9	.73	2.24	.82	1.71	5.2
77-S	July 27	94:176:354	do	2.5	.73	2.24	.72	2.23	6.0
78-S	do	94:176:354	do	1.2	.64	2.24	.73	2.14	6.1
79-V	do	94:176:354	do	1.0	.64	2.24	.73	2.14	6.1
80-V	do	94:176:409	do	2.4	.73	2.24	.77	1.93	5.5
81-V	do	94:176:436	do	1.7	.73	2.24	.79	1.81	5.4
82-V	do	94:176:463	do	1.1	.73	2.24	.82	1.71	5.2
83-S	July 30	94:176:354	do	3.0	.71	2.24	.72	2.21	6.0
84-S	do	94:176:354	do	1.4	.61	2.24	.74	2.12	6.1
85-V	do	94:176:354	do	1.4	.61	2.24	.74	2.12	6.1
86-V	do	94:192:409	do	1.5	.71	2.45	.76	2.00	5.4
87-V	do	94:200:436	do	1.2	.71	2.55	.77	1.91	5.2
88-V	do	94:209:463	do	.9	.71	2.67	.79	1.85	5.0
89-S	July 31	94:209:340	Stone	2.4	.79	2.67	.72	1.96	5.9
90-S	do	94:209:340	do	1.4	.73	2.67	.73	1.92	6.0

[1] Symbols used indicate:
S=Standard finish.
V=Vibrated.
W/C=Water-cement ratio by volume.
a/c=Sand-cement ratio by absolute volume.
b/b_0=Workability factor—ratio of the absolute volume of coarse aggregate in a unit volume of concrete to the absolute volume of coarse aggregate in a unit volume of coarse aggregate (dry and rodded basis).
M/V=Ratio of the absolute volume of mortar in a unit volume of concrete to the volume of the voids in the coarse aggregate in the same unit volume of concrete (dry and rodded basis).

TABLE 3.—*Data on mixes*—Continued

Section no.	Date laid (1934)	Proportions by weight	Coarse aggregate	Slump	W/C	a/c	b/b_0	M/V	Cement factor
		Pounds		*Inches*					*Sacks per cubic yard*
91-V	July 31	94:209:340	Stone	1.2	0.73	2.67	0.73	1.92	6.0
92-V	do	94:209:391	do	1.6	.79	2.67	.78	1.70	5.6
93-V	do	94:209:417	do	1.1	.79	2.67	.81	1.60	5.4
94-V	do	94:209:443	do	.7	.79	2.67	.83	1.51	5.2
95-S	Aug. 1	94:209:340	do	3.0	.84	2.67	.71	2.00	5.8
96-S	do	94:209:340	do	1.3	.74	2.67	.73	1.92	6.0
97-V	do	94:209:340	do	1.2	.74	2.67	.73	1.92	6.0
98-V	do	94:209:391	do	2.1	.84	2.67	.77	1.74	5.5
99-V	do	94:209:417	do	2.0	.84	2.67	.80	1.63	5.3
100-V	do	94:209:443	do	1.1	.84	2.67	.82	1.53	5.2
101-S	Aug. 2	94:176:354	Gravel	2.4	.72	2.24	.72	2.22	6.0
102-S	do	94:176:354	do	1.0	.63	2.24	.73	2.13	6.1
103-V	do	94:176:354	do	1.0	.63	2.24	.73	2.13	6.1
104-V	do	94:176:409	do	1.9	.72	2.24	.77	1.93	5.5
105-V	do	94:176:436	do	1.5	.72	2.24	.80	1.80	5.4
106-V	do	94:176:463	do	1.1	.72	2.24	.82	1.70	5.2
107-S	Aug. 3	94:176:354	do	2.6	.70	2.24	.72	2.20	6.0
108-S	do	94:176:354	do	1.2	.61	2.24	.74	2.12	6.1
109-V	do	94:176:354	do	1.0	.61	2.24	.74	2.12	6.1
110-V	do	94:176:409	do	1.8	.70	2.24	.77	1.91	5.6
111-V	do	94:176:436	do	1.4	.70	2.24	.80	1.79	5.4
112-V	do	94:176:463	do	1.0	.70	2.24	.82	1.68	5.2
113-S	Aug. 6	94:176:354	do	2.2	.73	2.24	.72	2.23	6.0
114-S	do	94:176:354	do	1.2	.64	2.24	.73	2.14	6.1
115-V	do	94:176:354	do	1.0	.64	2.24	.73	2.14	6.1
116-V	do	94:163:376	do	1.4	.67	2.08	.76	1.98	6.0
117-V	do	94:163:376	do	.9	.63	2.08	.77	1.95	6.0
118-V	do	94:146:392	do	1.2	.64	1.88	.80	1.78	6.0
119-V	do	94:146:392	do	.6	.64	1.88	.80	1.78	6.0
120-S	Aug. 7	94:176:354	do	3.0	.76	2.24	.71	2.26	5.9
121-S	do	94:176:354	do	1.2	.66	2.24	.73	2.16	6.1
122-V	do	94:176:354	do	1.0	.66	2.24	.73	2.16	6.1
123-V	do	94:163:376	do	1.6	.67	2.08	.76	1.98	6.0
124-V	do	94:163:376	do	.8	.63	2.08	.77	1.95	6.0
125-V	do	94:146:392	do	1.4	.66	1.88	.80	1.80	6.0
126-V	do	94:146:392	do	.8	.64	1.88	.80	1.78	6.0
127-S	Aug. 8	94:176:354	do	2.8	.75	2.24	.71	2.26	5.9
128-S	do	94:176:354	do	1.2	.68	2.24	.73	2.18	6.0
129-V	do	94:176:354	do	1.2	.68	2.24	.73	2.18	6.0
130-V	do	94:176:409	do	2.2	.75	2.24	.77	1.95	5.5
131-V	do	94:176:436	do	1.9	.75	2.24	.79	1.83	5.3
132-V	do	94:176:463	do	1.3	.75	2.24	.81	1.72	5.2
133-S	Aug. 9	94:176:354	do	2.4	.75	2.24	.71	2.25	5.9
134-S	do	94:176:354	do	1.2	.69	2.24	.72	2.19	6.0
135-V	do	94:176:354	do	1.2	.69	2.24	.72	2.19	6.0
136-V	do	94:192:409	do	1.1	.75	2.45	.75	2.03	5.4
137-V	do	94:200:436	do	.8	.75	2.55	.77	1.95	5.2
138-V	do	94:209:463	do	.8	.78	2.67	.78	1.90	4.9
139-S	Aug. 10	94:209:340	Stone	3.2	.82	2.67	.72	1.98	5.9
140-S	do	94:209:340	do	1.2	.71	2.67	.73	1.90	6.0
141-V	do	94:209:340	do	1.2	.71	2.67	.73	1.90	6.0
142-V	do	94:209:391	do	2.4	.82	2.67	.78	1.72	5.5
143-V	do	94:209:417	do	1.5	.82	2.67	.80	1.62	5.4
144-V	do	94:209:443	do	1.0	.82	2.67	.83	1.52	5.2
145-S	Aug. 13	94:209:340	do	2.6	.80	2.67	.72	1.97	5.9
146-S	do	94:209:340	do	1.2	.70	2.67	.74	1.89	6.0
147-V	do	94:209:340	do	1.0	.70	2.67	.74	1.89	6.0
148-V	do	94:209:391	do	2.0	.80	2.67	.78	1.71	5.5
149-V	do	94:209:417	do	1.4	.80	2.67	.81	1.60	5.4
150-V	do	94:209:443	do	1.0	.80	2.67	.83	1.51	5.2
151-S	Aug. 14	94:209:340	do	2.7	.80	2.67	.72	1.97	5.9
152-S	do	94:209:340	do	1.1	.70	2.67	.74	1.89	6.0
153-V	do	94:209:340	do	1.2	.70	2.67	.74	1.89	6.0
154-V	do	94:224:391	do	1.8	.80	2.86	.77	1.77	5.4
155-V	do	94:231:417	do	1.2	.80	2.94	.79	1.69	5.2
156-V	do	94:239:443	do	.8	.80	3.04	.80	1.62	5.0
157-S	Aug. 15	94:209:340	do	2.8	.81	2.67	.72	1.98	5.9
158-S	do	94:209:340	do	1.1	.70	2.67	.74	1.89	6.0
159-V	do	94:209:340	do	1.0	.70	2.67	.74	1.89	6.0
160-V	do	94:224:391	do	1.8	.81	2.86	.76	1.78	5.4
161-V	do	94:231:417	do	1.3	.81	2.94	.78	1.69	5.2
162-V	do	94:239:443	do	.8	.81	3.04	.80	1.62	5.0
163-S	Aug. 16	94:209:340	do	3.0	.78	2.67	.72	1.95	5.9
164-S	do	94:209:340	do	1.5	.68	2.67	.74	1.88	6.1
165-V	do	94:209:340	do	1.2	.68	2.67	.74	1.88	6.1
166-V	do	94:194:360	do	1.4	.68	2.47	.78	1.70	6.0
167-V	do	94:194:360	do	.8	.65	2.47	.79	1.68	6.1
168-V	do	94:177:378	do	1.5	.67	2.27	.82	1.54	6.0
169-V	do	94:177:378	do	.9	.64	2.27	.83	1.52	6.1
170-S	Aug. 17	94:209:340	do	2.9	.75	2.67	.73	1.93	6.0
171-S	do	94:209:340	do	1.4	.66	2.67	.74	1.86	6.1
172-V	do	94:209:340	do	1.4	.66	2.67	.74	1.86	6.1
173-V	do	94:194:360	do	1.6	.66	2.47	.78	1.69	6.1
174-V	do	94:194:360	do	.6	.62	2.47	.79	1.66	6.1
175-V	do	94:177:378	do	1.5	.65	2.27	.82	1.53	6.1
176-V	do	94:177:378	do	.8	.61	2.27	.83	1.50	6.1
177-S	Aug. 22	94:209:340	do	2.6	.80	2.67	.72	1.97	5.9
178-S	do	94:209:340	do	1.1	.70	2.67	.74	1.89	6.0
179-V	do	94:209:340	do	1.1	.70	2.67	.74	1.89	6.0
180-V	do	94:209:391	do	1.9	.81	2.67	.78	1.72	5.5
181-V	do	94:209:417	do	1.4	.81	2.67	.81	1.61	5.4
182-V	do	94:209:443	do	1.0	.81	2.67	.83	1.52	5.2
183-S	Aug. 23	94:176:354	Gravel	2.8	.74	2.24	.72	2.24	5.9
184-S	do	94:176:354	do	1.0	.63	2.24	.73	2.13	6.1
185-V	do	94:176:354	do	1.2	.63	2.24	.73	2.13	6.1
186-V	do	94:163:376	do	1.1	.61	2.08	.77	1.93	6.0
187-V	do	94:163:376	do	.7	.59	2.08	.78	1.91	6.1
188-V	do	94:146:392	do	1.0	.60	1.88	.81	1.75	6.1
189-V	do	94:146:392	do	.7	.58	1.88	.81	1.73	6.1
190-S	Aug. 24	94:176:354	do	2.6	.75	2.24	.71	2.25	5.9
191-S	do	94:176:354	do	1.2	.64	2.24	.73	2.14	6.1
192-V	do	94:176:354	do	1.2	.64	2.24	.73	2.14	6.1

TABLE 3.—*Data on mixes*—Continued

Section no.	Date laid (1934)	Proportions by weight	Coarse aggregate	Slump	W/C	a/c	b/b₀	M/V	Cement factor
		Pounds		*Inches*					*Sacks per cubic yard*
193-V	Aug. 24	94:163:376	Gravel	1.6	0.66	2.08	.76	1.97	6.0
194-V	do	94:163:376	do	.9	.62	2.08	.77	1.94	6.0
195-V	do	94:146:392	do	1.4	.63	1.88	.80	1.77	6.0
196-V	do	94:146:392	do	.8	.59	1.88	.81	1.74	6.1
197-S	Aug. 27	94:176:354	do	2.8	.76	2.24	.71	2.26	5.9
198-S	do	94:176:354	do	1.4	.68	2.24	.73	2.18	6.0
199-V	do	94-176-354	do	1.4	.68	2.24	.73	2.18	6.0
200-V	do	94:176:409	do	2.4	.76	2.24	.76	1.96	5.5
201-V	do	94:176:436	do	1.6	.76	2.24	.79	1.84	5.3
202-V	do	94:176:463	do	1.4	.76	2.24	.81	1.73	5.2
203-S	Aug. 28	94:176:354	do	3.1	.73	2.24	.72	2.23	6.0
204-S	do	94:176:354	do	1.2	.65	2.24	.73	2.15	6.1
205-V	do	94:176:354	do	1.2	.65	2.24	.73	2.15	6.1
206-V	do	94:176:409	do	2.2	.73	2.24	.77	1.93	5.5
207-V	do	94:176:436	do	2.0	.73	2.24	.79	1.81	5.4
208-V	do	94:176:463	do	1.6	.73	2.24	.82	1.71	5.2
209-S	Aug. 29	94:176:354	do	2.2	.68	2.24	.73	2.18	6.0
210-S	do	94:176:354	do	1.3	.64	2.24	.73	2.14	6.1
211-V	do	94:176:354	do	1.3	.64	2.24	.73	2.14	6.1
212-V	do	94:176:409	do	1.5	.68	2.24	.78	1.89	5.6
213-V	do	94:176:436	do	1.0	.68	2.24	.80	1.77	5.4
214-V	do	94:176:463	do	.9	.68	2.24	.82	1.67	5.2
215-S	Aug. 30	94:176:354	do	2.4	.73	2.24	.72	2.23	6.0
216-S	do	94:176:354	do	1.0	.65	2.24	.73	2.15	6.1
217-V	do	94:176:354	do	1.0	.65	2.24	.73	2.15	6.1
218-V	do	94:176:409	do	1.3	.73	2.24	.77	1.93	5.5
219-V	do	94:176:436	do	1.0	.73	2.24	.79	1.81	5.4
220-V	do	94:176:463	do	.8	.73	2.24	.82	1.71	5.2
221-S	Aug. 31	94:176:354	do	2.4	.72	2.24	.72	2.22	6.0
222-S	do	94:176:354	do	1.3	.64	2.24	.73	2.14	6.1
223-V	do	94:176:354	do	1.2	.64	2.24	.73	2.14	6.1
224-V	do	94:192:409	do	1.4	.72	2.45	.75	2.01	5.4
225-V	do	94:200:436	do	1.0	.72	2.55	.77	1.92	5.2
226-V	do	94'209:463	do	.8	.71	2.67	.79	1.85	5.0
227-S	Sept. 4	94:209:340	Stone	2.5	.74	2.67	.73	1.92	6.0
228-S	do	94:209:340	do	1.2	.66	2.67	.74	1.86	6.1
229-V	do	94:209:340	do	1.3	.66	2.67	.74	1.86	6.1
230-V	do	94:209:391	do	1.9	.74	2.67	.79	1.67	5.6
231-V	do	94:209:417	do	1.7	.74	2.67	.82	1.57	5.4
232-V	do	94:209:443	do	1.4	.74	2.67	.84	1.48	5.3
233-S	Sept. 5	94:209:340	do	2.4	.75	2.67	.73	1.93	6.0
234-S	do	94:209:340	do	1.0	.64	2.67	.75	1.85	6.1
235-V	do	94:209:340	do	1.0	.64	2.67	.75	1.85	6.1
236-V	do	94:209:391	do	1.4	.74	2.67	.79	1.67	5.6
237-V	do	94:209:417	do	1.4	.74	2.67	.82	1.57	5.4
238-V	do	94:209:443	do	1.0	.74	2.67	.84	1.48	5.3
239-S	Sept. 6	94:209:340	do	2.9	.74	2.67	.73	1.92	6.0
240-S	do	94:209:340	do	1.2	.64	2.67	.75	1.85	6.1
241-V	do	94:209:340	do	1.2	.64	2.67	.75	1.85	6.1
242-V	do	94:224:391	do	2.0	.74	2.86	.78	1.73	5.5
243-V	do	94:231:417	do	1.5	.74	2.94	.80	1.65	5.3
244-V	do	94:239:443	do	1.0	.74	3.04	.81	1.58	5.1
245-S	Sept. 10	94:209:340	do	1.4	.71	2.67	.73	1.90	6.0
246-V	do	94:209:340	do	1.7	.71	2.67	.73	1.90	6.0
247-S	do	94:209:340	do	3. 1	.77	2.67	.73	1.95	5.9
248-V	do	94:209:391	do	2.6	.77	2.67	.79	1.69	5.6
249-V	do	94:209:417	do	1.8	.77	2.67	.81	1.59	5.4
250-V	do	94:209:443	do	1.8	.77	2.67	.83	1.49	5.2
251-S	Sept. 11	94:209:340	do	2.6	.76	2.67	.73	1.94	5.9
252-S	do	94:209:340	do	1.1	.69	2.67	.74	1.89	6.0
253-V	do	94:209:340	do	1.0	.69	2.67	.74	1.89	6.0
254-V	do	94:209:443	do	1.2	.76	2.67	.84	1.49	5.3
255-S	Sept. 20	94:209:340	do	2.1	.74	2.67	.73	1.92	6.0
256-S	do	94:209:340	do	1.1	.68	2.67	.74	1.88	6.1
257-V	do	94:209:340	do	1.2	.68	2.67	.74	1.88	6.1
258-V	do	94:209:443	do	.8	.74	2.67	.84	1.48	5.3
259-S	Sept. 24	94:209:340	do	2.8	.75	2.67	.73	1.93	6.0
260-S	do	94:209:340	do	1.4	.67	2.67	.74	1.87	6.1
261-V	do	94:209:340	do	1.6	.67	2.67	.74	1.87	6.1
262-V	do	94:209:391	do	2.0	.74	2.67	.79	1.67	5.6
263-V	do	94:209:417	do	1.2	.70	2.67	.82	1.54	5.5
264-V	do	94:209:443	do	.8	.69	2.67	.85	1.45	5.3
265-S	Sept. 25	94:209:340	do	1.6	.72	2.67	.73	1.91	6.0
266-S	do	94:209:340	do	2.3	.75	2.67	.73	1.93	6.0
267-V	do	94:209:340	do	1.6	.72	2.67	.73	1.91	6.0
268-V	do	94:209:391	do	1.6	.75	2.67	.79	1.68	5.6
269-V	do	94:209:417	do	1.4	.75	2.67	.81	1.57	5.4
270-V	do	94:209:443	do	.8	.75	2.67	.84	1 48	5.3

In designating variations of the base mix for vibration, the possibility of effecting economies through cement saving was considered as well as the question of improving quality. In order to obtain the comparisons desired, the base mix was varied in three different ways. In one variation coarse aggregate only was added to the base mix, the water-cement ratio and the sand-cement ratio remaining constant. This resulted in reducing the cement content and slump in proportion to the amount of coarse aggregate added. In another variation the quantities of both fine and coarse aggregate were increased, the water-cement ratio remaining constant and the cement content and slump being still further reduced. In the third variation the cement content was held constant and the water-cement and sand-cement ratios reduced. The mix characteristics of each section as well as the date laid and the method of finishing are shown in table 3.

Referring to table 3, it will be noted that either six or seven sections were constructed during each day's run. The first three included: (1) The base mix, standard finish, at approximately 2½-inch slump; (2) the base mix, standard finish, reduced to about 1-inch slump by lowering the water-cement ratio; and (3) the same mix as (2) except that the concrete was vibrated. The proportions used in the balance of the sections in each day's run were variations of the base mix as indicated in table 3. All of these were vibrated. It will be observed that the base mix, standard finish, in terms of which all of the other sections were rated, was repeated each day. In this way it was possible to eliminate entirely from the comparisons the effect of differences in quality resulting from variable weather conditions during the progress of the work. It is believed that this procedure, although it added considerably to the volume of the work, materially increased its value.

Departing from the practice formerly employed, the concrete was deposited in two layers in a manner similar to that used when mesh reinforcing is to be installed. The longitudinal wooden separators were placed in position after the first batch was deposited and spread to approximately one-half the depth of the section. The second batch was then deposited and spread in the usual way. In series A each bucket was dumped by moving it laterally across the end of the section farthest from the mixer. The concrete was spread with the finishing machine, using a special strike-off for the first layer.

This method of dumping the concrete was criticized as not being comparable to the usual field practice. Consequently, in series B and C, this part of the procedure was changed by dumping each batch in the center of the section at the end farthest from the mixer and using the bucket to spread the concrete toward the mixer. This spread the concrete to a width of approximately 6 feet and was followed by hand shoveling both ways to the forms and with final strike-off by the machine. Figure 1 illustrates the method of depositing the batch used in series A and in series B and C.

STRENGTH AND HONEYCOMBING OF CONCRETE SLABS MEASURED

All of the 7-inch slabs were tested in the field as simple beams with the load applied at the third points of a 54-inch span. Details regarding the apparatus and methods used will be found in earlier reports on the subject.[2 3] The 10-inch slabs were brought to the laboratory and tested in a 200,000-pound universal testing machine, the required breaking loads being beyond the capacity of the field apparatus. Insofar as the span length and point of application of load were concerned, the same procedure was followed as was used with the 7-inch specimens. All flexure specimens were approximately 9½ months old when tested.

Five cores, 6 inches in diameter, were drilled from each test section, three for density and absorption tests and two for crushing strength tests. Specimens tested for density were drilled from slabs 1, 3, and 5. (See

[2] The Effect of Vibration and Delayed Finishing on Pavement Slabs. PUBLIC ROADS, vol. 14, no. 8, October 1933.

[3] Studies of Paving Concrete, by F. H. Jackson and W. F. Kellerman. PUBLIC ROADS, vol. 12, no. 6, August 1931.

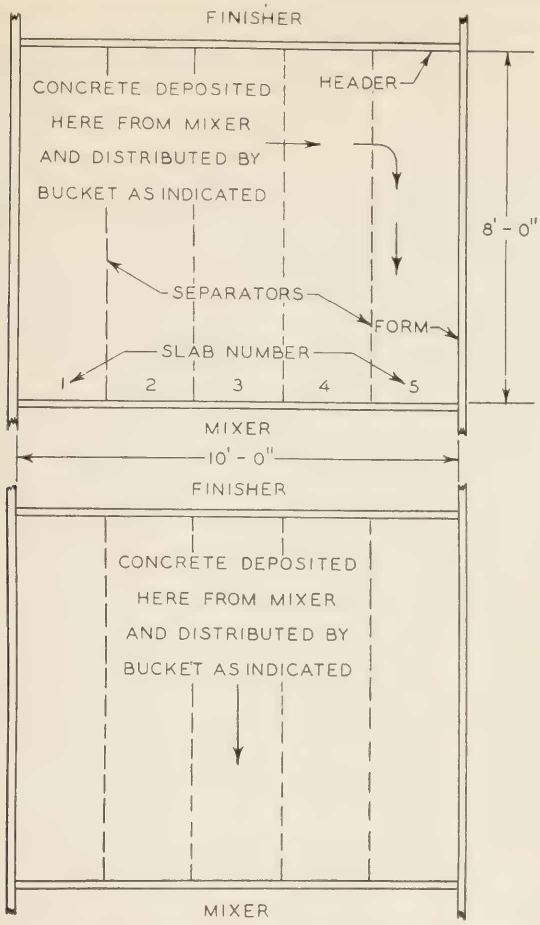


FIGURE 1.—SKETCH SHOWING HOW CONCRETE WAS DEPOSITED ON SUBGRADE BY MIXER DISCHARGE BUCKET.

fig. 1.) In the case of the cores for strength tests, one was drilled from slab 3 and one was drilled from either slab 1 or 5. This was done so that concrete from the center and both sides of the test section would be represented. All cores were drilled from broken slabs, care being taken to select concrete free from honeycomb. Absorption values were computed on the basis of 5 hours' immersion in boiling water. Compression and absorption tests were made when the specimens were approximately 14 months old.

The results of the flexure tests on the individual 24-inch slabs are given in table 4, which shows also the percentage of variation of each value from the average for the section as well as the average variation for the section.

The percentages of honeycomb in the bottom surface and at the cross-section where failure in flexure occurred are given for each test slab in table 5. In general, the same procedure was used for measuring the amount of honeycomb as was employed in the earlier work.[2] For the purpose of determining the rating of each section, an average of the 10 determinations, 5 on the bottom and 5 at the break, was obtained. These are the values which are indicated in the various charts.

Figures 2 to 5, inclusive, illustrate the distribution of honeycomb on the bottom surface of typical sections (series B) representing concrete of medium versus dry consistency, and standard finish versus vibrated.

[2] The Effect of Vibration and Delayed Finishing on Pavement Slabs. PUBLIC ROADS, vol. 14, no. 8, October 1933.

TABLE 4.—*Individual slab strength and uniformity*

Section no.	Modulus of rupture of slab no.—						Variation from average					
	1	2	3	4	5	Average	1	2	3	4	5	Average
	Lb. per sq. in.	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
1	698	721	703	739	675	707	1.3	2.0	0.6	4.5	4.5	2.6
2	749	751	674	652	650	695	7.8	8.1	3.0	6.2	6.5	6.3
3	676	671	703	659	703	682	.9	1.6	3.1	3.4	3.1	2.4
4	628	607	637	637	708	643	2.3	5.6	.9	.9	10.1	4.0
5	669	712	677	723	701	696	3.9	2.3	2.7	3.9	.7	2.7
6	623	615	635	674	664	642	3.0	4.2	1.1	5.0	3.4	3.3
7	694	769	726	574	662	685	1.3	12.3	6.0	16.2	3.4	7.8
8	658	752	667	684	678	688	4.4	9.3	3.1	.6	1.5	3.8
9	729	750	701	704	672	711	2.5	5.5	1.4	1.0	5.5	3.2
10	625	738	687	643	672	673	7.1	9.7	2.1	4.5	.1	4.7
11	650	699	------	------	------	[1] 674	3.6	3.7	------	------	------	[1] 3.6
12	------	644	627	[2] 486	638	[1] 599	------	7.5	4.7	18.9	6.5	[1] 9.4
13	634	726	636	700	618	663	4.4	9.5	4.1	5.6	6.8	6.1
14	558	[2] 648	670	762	636	655	14.8	1.1	2.3	16.3	2.9	7.5
15	515	604	660	733	[2] 456	594	13.3	1.7	11.1	23.4	23.2	14.5
16	577	676	652	671	657	647	10.8	4.5	.8	3.7	1.5	4.3
17	594	------	685	709	656	[1] 661	10.1	------	3.6	7.3	.8	[1] 5.4
18	[2] 467	[2] 517	610	698	581	575	18.8	10.1	6.1	21.4	1.0	11.5
19	[2] 592	687	687	592	[2] 721	656	9.8	4.7	4.7	9.8	9.9	7.8
20	586	678	628	682	611	637	8.0	6.4	1.4	7.1	4.1	5.4
21	700	[2] 670	[2] 656	698	[2] 680	681	2.8	1.6	3.7	2.5	.1	2.1
22	721	678	723	648	706	695	3.7	2.4	4.0	6.8	1.6	3.7
23	667	710	685	693	707	692	3.6	2.6	1.0	.1	2.2	1.9
24	610	667	639	696	669	656	7.0	1.7	2.6	6.1	2.0	3.9
25	664	615	703	700	747	686	3.2	10.4	2.5	2.0	8.9	5.4
26	547	565	691	643	566	602	9.1	6.1	14.8	6.8	6.0	8.6
27	737	832	778	753	652	750	1.7	10.9	3.7	.4	13.1	6.0
28	722	724	721	742	652	712	1.4	1.7	1.3	4.2	8.4	3.4
29	687	699	748	750	693	715	3.9	2.2	4.6	4.9	3.1	3.7
30	663	709	683	797	709	712	6.9	.4	4.1	11.9	.4	4.7
31	833	890	836	910	936	881	5.4	1.0	5.1	3.3	6.2	4.2
32	851	821	859	997	902	886	3.9	7.3	3.0	12.5	1.8	5.7
33	968	972	976	1,028	1,045	998	3.0	2.6	2.2	3.0	4.7	3.1
34	857	851	890	950	871	884	3.1	3.7	.7	7.5	1.5	3.3
35	804	830	[2] 905	843	957	868	7.4	4.4	4.3	2.9	10.3	5.9
36	799	785	830	913	935	852	6.2	7.9	2.6	7.2	9.7	6.7
37	787	747	717	942	986	836	5.9	10.6	14.2	12.7	17.9	12.3
38	848	875	799	------	984	[1] 876	3.2	.1	8.8	------	12.3	[1] 6.1
39	997	985	979	996	986	989	.8	.4	1.0	.7	.3	.6
40	961	896	908	------	1,043	[1] 952	.9	5.9	4.6	------	9.6	[1] 5.2
41	851	818	811	754	1,008	848	.3	3.5	4.4	11.1	18.9	7.6
42	678	774	796	869	871	798	15.0	3.0	.3	8.9	9.1	7.3
43	897	869	896	903	916	896	.1	3.0	0	.8	2.2	1.2
44	964	946	924	------	838	[1] 918	5.0	3.0	.7	------	8.7	[1] 4.4
45	845	865	945	914	921	898	5.9	3.7	5.2	1.8	2.6	3.8
46	790	862	921	902	958	887	10.9	2.8	3.8	1.7	8.0	5.4
47	960	974	832	940	931	927	3.6	5.1	10.3	1.4	.4	4.2
48	920	909	1,037	889	898	931	1.2	2.4	11.4	4.5	3.5	4.6
49	975	------	986	974	957	[1] 973	.2	------	1.3	.1	1.6	1.8
50	896	925	862	888	899	894	.2	3.5	3.6	.7	.6	1.7
51	927	932	908	886	------	[1] 913	1.5	2.1	.5	3.0	------	[1] 1.8
52	952	745	965	991	928	916	3.9	18.7	5.3	8.2	1.3	7.5
53	929	990	1,001	945	1,002	973	4.5	1.7	2.9	2.9	3.0	3.0
54	1,048	745	1,024	897	890	921	13.8	19.1	11.2	2.6	3.4	10.0
55	913	739	985	896	892	885	3.2	16.5	11.3	1.2	.8	6.6
56	799	1,003	------	857	850	[1] 877	8.9	14.4	------	2.3	3.1	[1] 7.2
57	679	647	------	720	643	[1] 672	1.0	3.7	------	7.1	4.3	[1] 4.0
58	690	799	787	751	734	752	8.2	6.3	4.7	.1	2.4	4.3
59	726	892	768	751	715	770	5.8	15.8	.3	2.5	7.2	6.3
60	780	801	751	756	735	765	2.0	4.7	1.8	1.2	3.9	2.7
61	691	642	780	694	647	691	0	7.1	12.9	.4	6.4	5.4
62	704	679	701	710	697	698	.9	2.7	.4	1.7	.1	1.2
63	669	722	798	745	733	733	8.7	1.5	8.9	1.6	0	4.1
64	[2] 720	735	741	714	719	726	.8	1.2	2.1	1.7	1.0	1.4
65	746	765	737	704	773	745	.1	2.7	1.1	5.5	3.8	2.6
66	758	769	782	777	729	763	.7	.8	2.5	1.8	4.5	2.1
67	753	768	718	755	737	746	.9	3.0	3.8	1.2	1.2	2.0
68	756	731	795	[2] 778	709	754	.3	3.0	5.4	3.2	6.0	3.6
69	791	694	753	781	762	756	4.6	8.2	.4	3.3	.8	3.5
70	712	677	712	683	724	702	1.4	3.6	1.4	2.7	3.1	2.4
71	662	635	716	689	670	674	1.8	5.8	6.2	2.2	.6	3.3
72	699	745	731	728	698	720	2.9	3.5	1.5	1.1	3.1	2.4
73	645	715	763	733	632	698	7.6	2.4	9.3	5.0	9.5	6.8
74	658	636	656	666	676	658	0	3.3	.3	1.2	2.7	1.5
75	641	717	715	691	[2] 571	667	3.9	7.5	7.2	3.6	14.4	7.3
76	619	690	702	702	626	668	7.3	3.3	5.1	5.1	6.3	5.4
77	691	717	776	679	652	703	1.7	2.0	10.4	3.4	7.3	5.0
78	643	774	718	702	651	698	7.9	10.9	2.9	.6	6.7	5.8
79	[2] 664	745	796	715	640	712	6.7	4.6	11.8	.4	10.1	6.7
80	637	700	645	658	670	662	3.8	5.7	2.6	.6	1.2	2.8
81	640	759	679	727	661	693	7.6	9.5	2.0	4.9	4.6	5.7
82	647	715	701	678	636	675	4.1	5.9	3.9	.4	5.8	4.0
83	654	668	639	675	687	665	1.7	.5	3.9	1.5	3.3	2.2
84	718	740	738	736	[2] 738	734	2.2	.8	.5	.3	.5	.9
85	585	761	725	724	709	701	16.5	8.6	3.4	3.3	1.1	6.6
86	650	677	667	713	655	672	3.3	.7	.7	6.1	2.5	2.7
87	598	606	614	615	613	609	1.8	.5	.8	1.0	.7	1.0
88	581	688	690	640	595	639	9.1	7.7	8.0	.2	6.9	6.4
89	792	752	------	852	781	[1] 794	.3	5.3	------	7.3	1.6	[1] 3.6
90	756	879	[2] 877	845	729	817	7.5	7.6	7.3	3.4	10.8	7.3
91	813	817	813	808	809	812	.1	.6	.1	.5	.4	.3
92	799	760	798	759	720	767	4.2	.9	4.0	1.0	6.1	3.2
93	722	901	873	811	764	814	11.3	10.7	7.2	.4	6.1	7.1
94	717	777	831	834	744	781	8.2	.5	6.4	6.8	4.7	5.3
95	673	659	689	669	707	679	.9	2.9	1.5	1.5	4.1	2.2
96	588	785	899	718	[2] 578	714	17.6	9.9	25.9	.6	19.0	14.6
97	680	810	848	840	660	768	11.5	5.5	10.4	9.4	14.1	10.2
98	702	712	786	772	687	732	4.1	2.7	7.4	5.5	6.1	5.2

[1] Average of less than 5 values.
[2] Broke outside middle third.

TABLE 4.—*Individual slab strength and uniformity*—Continued

Section no.	Modulus of rupture of slab no.—						Variation from average					
	1	2	3	4	5	Average	1	2	3	4	5	Average
	Lb. per sq. in.	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
99	649	750	789	799	624	722	10.1	3.9	9.3	10.7	13.6	9.5
100	562	761	839	801	619	716	21.5	6.3	17.2	11.9	13.6	14.1
101	526	568	553	561	560	554	5.1	2.5	.2	1.3	1.1	2.0
102	518	585	583	584	521	558	7.2	4.8	4.5	4.7	6.6	5.6
103	641	648	644	663	542	628	2.1	3.2	2.6	5.6	13.7	5.4
104	[2] 560	641	676	562	607	609	8.0	5.3	11.0	7.7	.3	6.5
105	531	616	624	630	578	596	10.9	3.4	4.7	5.7	3.0	5.5
106	------	614	583	631	503	[1] 583	------	5.3	0	8.2	13.7	[1] 6.8
107	651	626	699	673	663	662	1.7	5.4	5.6	1.7	.2	2.9
108	628	705	705	696	695	686	8.5	2.8	2.8	1.5	1.3	3.4
109	736	725	776	662	675	715	2.9	1.4	8.5	7.4	5.6	5.2
110	652	683	697	669	634	667	2.3	2.4	4.5	.3	5.0	2.9
111	711	707	663	609	650	668	6.4	5.8	.7	8.8	2.7	4.9
112	563	663	644	567	553	598	5.9	10.9	7.7	5.2	7.5	7.4
113	620	694	634	674	576	640	3.1	8.4	.9	5.3	10.0	5.5
114	585	731	729	681	648	675	13.3	8.3	8.0	.9	4.0	6.9
115	645	730	705	813	765	732	11.9	.3	3.7	11.1	4.5	6.3
116	698	660	781	767	668	715	2.4	7.7	9.2	7.3	6.6	6.6
117	637	578	741	744	756	691	7.8	16.4	7.2	7.7	9.4	9.7
118	725	719	747	754	652	719	.8	0	3.9	4.9	9.3	3.8
119	708	766	787	758	[2] 690	742	4.6	3.2	6.1	2.2	7.0	4.6
120	676	680	660	681	660	671	.7	1.3	1.6	1.5	1.6	1.3
121	758	720	746	739	729	738	2.7	2.4	1.1	.1	1.2	1.5
122	687	791	795	787	665	745	7.8	6.2	6.7	5.6	10.7	7.4
123	740	702	704	678	668	698	6.0	.6	.9	2.9	4.3	2.9
124	675	765	810	777	680	741	8.9	3.2	9.3	4.9	8.2	6.9
125	742	716	736	779	659	726	2.2	1.4	1.4	7.3	9.2	4.3
126	721	699	797	805	662	737	2.2	5.2	8.1	9.2	10.2	7.0
127	701	617	671	611	711	662	5.9	6.8	1.4	7.7	7.4	5.8
128	649	[2] 659	720	688	[2] 578	659	1.5	0	9.3	4.4	12.3	5.5
129	722	[2] 729	[2] 688	765	689	719	.4	1.4	4.3	6.4	4.2	3.3
130	702	644	631	695	608	656	7.0	1.8	3.8	5.9	7.3	5.2
131	716	625	709	677	711	688	4.1	9.2	3.1	1.6	3.3	4.3
132	683	594	646	669	609	640	6.7	7.2	.9	4.5	4.8	4.8
133	656	625	675	696	689	668	1.8	6.4	1.0	4.2	3.1	3.3
134	602	702	678	629	617	646	6.8	8.7	5.0	2.6	4.5	5.5
135	654	715	747	726	637	696	6.0	2.7	7.3	4.3	8.5	5.8
136	678	725	706	708	645	692	2.0	4.8	2.0	2.3	6.8	3.6
137	683	651	695	670	641	668	2.2	2.5	4.0	.3	4.0	2.6
138	628	624	695	690	635	654	4.0	4.6	6.3	5.5	2.9	4.7
139	747	824	769	782	707	766	2.5	7.6	.4	2.1	7.7	4.1
140	853	909	863	920	829	875	2.5	3.9	1.4	5.1	5.3	3.6
141	869	950	908	906	574	841	3.3	13.0	8.0	7.7	31.7	12.7
142	891	794	[2] 724	728	832	794	12.2	0	8.8	8.3	4.8	6.8
143	869	758	841	850	801	824	5.5	8.0	2.1	3.2	2.8	4.3
144	814	864	845	860	731	823	1.1	5.0	2.7	4.5	11.2	4.9
145	806	847	832	819	894	840	4.0	.8	1.0	2.5	6.4	2.9
146	794	882	925	912	805	864	8.1	2.1	7.1	5.6	6.8	5.9
147	848	888	968	957	878	908	6.6	2.2	6.6	5.4	3.3	4.8
148	833	821	832	840	789	823	1.2	.2	1.1	2.1	4.1	1.7
149	798	842	898	849	752	828	3.6	1.7	8.5	2.5	9.2	5.1
150	802	813	806	838	732	798	.5	1.9	1.0	5.0	8.3	3.3
151	863	959	838	822	859	868	.6	10.5	3.5	5.3	1.0	4.2
152	784	796	818	832	773	801	2.1	.6	2.1	3.9	3.5	2.4
153	864	914	[2] 808	935	793	863	.1	5.9	6.4	8.3	8.1	5.8
154	851	827	750	814	773	803	6.0	3.0	6.6	1.4	3.7	4.1
155	761	848	844	919	737	822	7.4	3.2	2.7	11.8	10.3	7.1
156	717	798	825	818	708	773	7.2	3.2	6.7	5.8	8.4	6.3
157	808	860	810	890	865	847	4.6	1.5	4.4	5.1	2.1	3.5
158	774	918	961	926	741	864	10.4	6.2	11.2	7.2	14.2	9.8
159	984	909	884	901	966	929	5.9	2.2	4.8	3.0	4.0	4.0
160	847	794	813	824	769	809	4.7	1.9	.5	1.9	4.9	2.8
161	820	935	862	960	797	875	6.3	6.9	1.5	9.7	8.9	6.7
162	787	849	935	902	794	853	7.7	.5	9.6	5.7	6.9	6.1
163	859	822	850	815	745	818	5.0	.5	3.9	.4	8.9	3.7
164	900	862	946	981	849	908	.9	5.1	4.2	8.0	6.5	4.9
165	755	962	896	886	865	873	13.5	10.2	2.6	1.5	.9	5.7
166	892	954	979	903	768	899	.8	6.1	8.9	.4	14.6	6.2
167	866	1,001	965	930	888	930	6.9	7.6	3.8	0	4.5	4.6
168	867	968	987	961	791	915	5.2	5.8	7.9	5.0	13.6	7.5
169	924	872	917	954	889	911	1.4	4.3	.7	4.7	2.4	2.7
170	820	799	827	796	760	800	2.5	.1	3.4	.5	5.0	2.3
171	744	869	810	868	821	822	9.5	5.7	1.5	5.6	.1	4.5
172	873	968	912	897	935	917	4.8	5.6	.5	2.2	2.0	3.0
173	951	931	959	1,005	896	948	.3	1.8	1.2	6.0	5.5	3.0
174	964	993	996	1,077	874	981	1.7	1.2	1.5	9.8	10.9	5.0
175	954	849	881	935	848	893	6.8	4.9	1.3	4.7	5.0	4.5
176	893	969	949	913	826	910	1.9	6.5	4.3	.3	9.2	4.4
177	831	856	819	827	820	831	0	3.0	1.4	.5	1.3	1.2
178	666	[2] 874	877	846	867	826	19.4	5.8	6.2	2.4	5.0	7.8
179	875	951	911	787	894	884	1.0	7.6	3.1	11.0	1.1	4.8
180	925	758	850	878	797	842	9.9	10.0	.9	4.3	5.3	6.1
181	849	789	873	896	823	846	.4	6.7	3.2	5.9	2.7	3.8
182	751	879	960	868	863	864	13.1	1.7	11.1	.5	.1	5.3
183	705	704	690	646	644	678	4.0	3.8	1.8	4.7	5.0	3.9
184	560	694	743	606	522	625	10.4	11.0	18.9	3.0	16.5	12.0
185	700	746	737	724	693	720	2.8	3.6	2.4	.6	3.7	2.6
186	692	744	791	699	645	714	3.1	4.2	10.8	2.1	9.7	6.0
187	742	723	736	601	677	696	6.6	3.9	5.7	13.6	2.7	6.5
188	709	767	748	716	651	718	1.3	6.8	4.2	.3	9.3	4.4
189	749	709	760	707	678	721	3.9	1.7	5.4	1.9	6.0	3.8
190	692	673	656	706	635	672	3.0	.1	2.4	5.1	5.5	3.2
191	620	706	721	718	645	682	9.1	3.5	5.7	5.3	5.4	5.8
192	741	701	712	697	709	712	4.1	1.5	0	2.1	.4	1.6
193	753	699	760	703	665	716	5.2	2.4	6.1	1.8	7.1	4.5
194	705	763	757	715	[2] 660	720	2.1	6.0	5.1	.7	8.3	4.4
195	731	735	734	695	682	715	2.2	2.8	2.7	2.8	4.6	3.0
196	663	708	670	722	662	685	3.2	3.4	2.2	5.4	3.4	3.5
197	663	704	721	682	697	693	4.3	1.6	4.0	1.6	.6	2.4
198	710	[2] 799	800	[2] 722	720	750	5.3	6.5	6.7	3.7	4.0	5.2
199	771	774	814	766	726	770	.1	.5	5.7	.5	5.7	2.5
200	[2] 597	650	734	689	657	665	10.2	2.3	10.4	3.6	1.2	5.5
201	637	631	719	700	657	669	4.8	5.7	7.5	4.6	1.8	4.9
202	704	647	692	706	608	671	4.9	3.6	3.1	5.2	9.4	5.2
203	601	613	632	669	612	625	3.8	1.9	1.1	7.0	2.1	3.2
204	496	670	699	704	453	604	17.9	10.9	15.7	16.6	25.0	17.2
205	[2] 578	674	713	610	647	644	10.2	4.7	10.7	5.3	.5	6.3
206	598	659	633	596	618	621	3.7	6.1	1.9	4.0	.5	3.2
207	577	619	625	632	572	605	4.6	2.3	3.3	4.5	5.5	4.0
208	639	610	665	591	584	618	3.4	1.3	7.6	4.4	5.5	4.4
209	728	682	[2] 675	678	691	691	5.4	1.3	2.3	1.9	0	2.2
210	[2] 659	677	758	718	703	703	6.3	3.7	7.8	2.1	0	4.0
211	701	751	736	763	750	740	5.3	1.5	.5	3.1	1.4	2.4
212	694	641	739	706	678	692	.3	7.4	6.8	2.0	2.0	3.7
213	[2] 651	756	731	726	741	721	9.7	4.9	1.4	.7	2.8	3.9
214	645	645	706	700	686	676	4.6	4.6	4.4	3.6	1.5	3.7
215	685	644	657	721	705	682	.4	5.6	3.7	5.7	3.4	3.8
216	[2] 615	742	642	[2] 627	650	655	6.1	13.3	2.0	4.3	.8	5.3
217	704	743	708	709	660	705	.1	5.4	.4	.6	6.4	2.6
218	744	690	669	717	687	701	6.1	1.6	4.6	2.3	2.0	3.3
219	632	556	[2] 692	683	703	653	3.2	14.9	6.0	4.6	7.7	7.3
220	651	692	681	710	703	687	5.2	.7	.9	3.3	2.3	2.5
221	628	704	666	699	718	683	8.1	3.1	2.5	2.3	5.1	4.2
222	626	660	725	683	646	668	6.3	1.2	8.5	2.2	3.3	4.3
223	700	688	680	713	704	697	.4	1.3	2.4	2.3	1.0	1.5
224	667	672	720	690	681	686	2.8	2.0	5.0	.6	.7	2.2
225	[2] 707	684	737	707	617	690	2.5	.9	6.8	2.5	10.6	4.7
226	600	666	682	643	624	643	6.7	3.6	6.1	0	3.0	3.9
227	827	826	[2] 831	814	764	812	1.8	1.7	2.3	.2	5.9	2.4
228	795	859	898	893	860	861	7.7	.2	4.3	3.7	.1	3.2
229	882	824	952	978	848	897	1.7	8.1	6.1	9.0	5.5	6.1
230	873	780	821	814	829	823	6.1	5.2	.2	1.1	.7	2.7
231	829	810	929	882	872	864	4.1	6.3	7.5	2.1	.9	4.2
232	752	799	885	852	797	817	8.0	2.2	8.3	4.3	2.4	5.0
233	916	859	856	915	703	850	7.8	1.1	.7	7.6	17.3	6.9
234	790	921	917	803	751	836	5.5	10.2	9.7	3.9	10.2	7.9
235	843	872	875	818	852	852	1.1	2.3	2.7	4.0	0	2.0
236	879	841	833	822	805	836	5.1	.6	.4	1.7	3.7	2.3
237	764	842	837	902	802	829	7.8	1.6	1.0	8.8	3.3	4.5
238	637	799	943	899	860	828	23.1	3.5	13.9	8.6	3.9	10.6
239	767	825	981	881	822	855	10.3	3.5	14.7	3.0	3.9	7.1
240	753	784	878	823	791	806	6.6	2.7	8.9	2.1	1.9	4.4
241	885	905	956	957	854	911	2.9	.7	4.9	5.0	6.3	4.0
242	853	834	856	868	851	852	.1	2.1	.5	1.9	.1	.9
243	865	794	823	747	737	793	9.1	.1	3.8	5.8	7.1	5.2
244	[2] 742	779	795	821	799	787	5.7	1.0	1.0	4.3	1.5	2.7
245	734	814	756	763	628	739	.7	10.2	2.3	3.2	15.0	6.3
246	703	768	852	714	823	772	8.9	.5	10.4	7.5	6.6	6.8
247	680	810	836	757	813	779	12.7	4.0	7.3	2.8	4.4	6.2
248	803	799	860	932	821	843	4.7	5.2	2.0	10.6	2.6	5.0
249	756	873	871	843	759	820	7.8	6.5	6.2	2.8	7.4	6.1
250	674	799	839	803	[2] 720	767	12.1	4.2	9.4	4.7	6.1	7.3
251	[2] 770	756	810	[2] 825	803	793	2.9	4.7	2.1	4.0	1.3	3.0
252	711	770	793	793	718	757	6.1	1.7	4.8	4.8	5.2	4.5
253	773	[2] 796	796	765	761	778	.6	2.3	2.3	1.7	2.2	1.8
254	732	806	831	773	710	770	4.9	4.7	7.9	.4	7.8	5.1
255	825	851	824	850	864	843	2.1	.9	2.3	.8	2.5	1.7
256	916	874	856	869	[2] 668	837	9.4	4.4	2.3	3.8	20.2	8.0
257	829	843	905	839	731	829	0	1.7	9.2	1.2	11.8	4.8
258	[2] 589	810	941	856	605	760	22.5	6.6	23.8	12.6	20.4	17.2
259	811	744	770	733	820	776	4.5	4.1	.8	5.5	5.7	4.1
260	856	871	824	820	807	836	2.4	4.2	1.4	1.9	3.5	2.7
261	891	878	[2] 895	888	895	889	.2	1.2	.7	.1	.7	.6
262	863	797	908	873	823	853	1.2	6.6	6.4	2.3	3.5	4.0
263	818	872	931	839	836	859	4.8	1.5	8.4	2.3	2.7	3.9
264	809	876	895	855	791	845	4.3	3.7	5.9	1.2	6.4	4.3
265	827	778	893	912	[2] 846	851	2.8	8.6	4.9	7.2	.6	4.8
266	929	902	827	866	865	878	5.8	2.7	5.8	1.4	1.5	3.4
267	879	830	855	832	835	846	3.9	1.9	1.1	1.7	1.3	2.0
268	812	878	843	908	792	847	4.1	3.7	.5	7.2	6.5	4.4
269	790	811	879	895	769	829	4.7	2.2	6.0	8.0	7.2	5.6
270	777	807	870	754	707	783	.8	3.1	11.1	3.7	9.7	5.7

[1] Average of less than 5 values. [2] Broke outside middle third.

Control flexure specimens consisting of four 7 by 7 by 30-inch beams were cast in connection with each standard-finish section up to section no. 151, after which a set of four beams was cast for every section. Three control cylinders, 6- by 12-inch, were cast for each section. None of the control specimens was vibrated. All were job cured and were the same age as the pavement slabs and the cores when tested. All specimens were tested wet. The results are shown in table 6 together with the corresponding average strengths of the pavement slabs and the cores.

Results of tests for bulk specific gravity and absorption are shown in table 7.

TABLE 5.—*Percentage of honeycomb in slabs*

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
1-1	17.1	0	15-1	92.4	13.5
2	1.1	0	2	82.3	8.0
3	0	0	3	25.6	0
4	7.4	0	4	34.2	0
5	22.1	0	5	67.7	7.3
Average	9.5	0	Average	60.4	5.8
2-1	7.5	0	16-1	39.8	2.6
2	1.4	0	2	9.4	0
3	2.4	0	3	17.4	0
4	28.6	.9	4	52.0	1.2
5	43.9	.6	5	13.5	2.0
Average	16.8	.3	Average	26.4	1.2
3-1	0	0	17-1	57.3	3.8
2	5.6	0	2	15.5	.3
3	7.0	0	3	7.7	0
4	14.0	0	4	12.7	0
5	42.0	0	5	45.1	.6
Average	13.7	0	Average	27.7	.9
4-1	4.3	0	18-1	61.8	15.4
2	0	0	2	34.0	6.0
3	0	0	3	31.7	.9
4	27.6	2.7	4	29.4	0
5	22.2	0	5	57.3	3.5
Average	10.8	.5	Average	42.8	5.2
5-1	7.2	0	19-1	17.8	4.0
2	4.7	0	2	1.7	0
3	2.8	0	3	15.6	0
4	.8	0	4	7.8	2.3
5	9.6	0	5	9.0	0
Average	5.0	0	Average	10.4	1.3
6-1	1.9	0	20-1	78.4	5.5
2	2.2	0	2	49.4	.9
3	8.3	0	3	52.8	4.4
4	21.0	0.9	4	48.3	.9
5	18.3	0	5	41.7	5.1
Average	10.3	.2	Average	54.1	3.4
7-1	15.9	.5	21-1	14.5	.3
2	0	0	2	2.2	0
3	0	0	3	11.4	.3
4	28.3	.5	4	1.7	0
5	13.4	.5	5	10.3	0
Average	11.5	.3	Average	8.0	.1
8-1	16.9	5.5	22-1	1.0	0
2	0	0	2	1.8	0
3	0	0	3	0	0
4	20.2	3.7	4	2.1	0
5	4.2	0	5	10.1	.3
Average	8.3	1.8	Average	3.0	.1
9-1	0	0	23-1	7.4	.3
2	0	0	2	0	0
3	0	0	3	0	0
4	0	0	4	7.6	0
5	4.2	0	5	9.2	0
Average	.8	0	Average	4.8	.1
10-1	0	0	24-1	17.4	.6
2	2.4	0	2	22.6	.6
3	3.5	0	3	21.2	2.1
4	3.8	0	4	23.8	0
5	3.6	0	5	51.2	.6
Average	2.7	0	Average	27.2	.8
11-1	0	0	25-1	3.9	0
2	0	0	2	7.9	0
3	0	0	3	10.5	0
4	12.3	0	4	15.2	0
5	2.2	0	5	23.9	0
Average	2.9	0	Average	12.3	0
12-1	0	0	26-1	67.6	8.6
2	0	0	2	47.3	4.2
3	2.9	.3	3	31.2	0
4	21.5	0	4	35.3	3.0
5	22.9	0	5	68.0	.3
Average	9.5	.1	Average	49.9	3.2
13-1	34.4	1.5	27-1	4.5	0
2	6.0	0	2	20.5	0
3	15.7	0	3	0	0
4	11.4	2.1	4	6.6	0
5	31.2	3.1	5	13.1	0
Average	19.7	1.3	Average	8.9	0
14-1	71.0	6.9	28-1	6.3	0
2	43.2	5.4	2	0	0
3	48.2	.6	3	0	0
4	59.7	.6	4	10.3	0
5	67.2	3.7	5	5.2	0
Average	57.9	3.4	Average	4.4	0

TABLE 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
29-1	20.2	2.4	43-1	7.4	0
2	4.7	0	2	10.8	0
3	1.9	0	3	3.0	0
4	13.1	0	4	14.8	0
5	5.1	0	5	8.7	1.2
Average	9.0	.5	Average	8.9	.2
30-1	33.8	4.1	44-1	29.5	0
2	4.4	0	2	13.8	0
3	4.4	0	3	0	0
4	16.1	0	4	36.7	3.0
5	25.3	0	5	39.5	4.9
Average	16.8	.8	Average	23.9	1.6
31-1	36.7	2.7	45-1	7.6	.3
2	5.6	0	2	12.8	.6
3	12.9	0	3	0	0
4	22.5	0	4	6.7	.6
5	21.0	0	5	0	0
Average	19.7	.5	Average	5.4	.3
32-1	42.8	8.7	46-1	7.5	0
2	16.0	5.8	2	17.7	0
3	38.2	1.1	3	3.5	0
4	17.9	0	4	2.4	0
5	17.5	.6	5	3.6	0
Average	26.5	3.2	Average	6.9	0
33-1	0	0	47-1	2.1	0
2	0	0	2	63.9	1.2
3	0	0	3	24.3	0
4	0	0	4	27.1	0
5	0	0	5	39.6	.9
Average	0	0	Average	31.4	.4
34-1	0	0	48-1	4.6	0
2	31.7	.6	2	36.8	0
3	18.3	.6	3	11.4	0
4	22.6	0	4	27.9	0
5	0	0	5	13.5	0
Average	14.5	.2	Average	18.8	0
35-1	35.4	.6	49-1	22.2	.6
2	11.8	1.2	2	24.6	1.2
3	26.9	0	3	8.8	.3
4	10.8	0	4	21.2	.6
5	5.5	0	5	35.6	1.2
Average	18.1	.4	Average	22.5	.8
36-1	16.5	0	50-1	27.9	1.2
2	57.8	5.1	2	3.8	0
3	37.4	.9	3	21.9	0
4	8.3	0	4	16.9	0
5	13.1	0	5	21.7	.9
Average	26.6	1.2	Average	18.4	.4
37-1	33.9	4.7	51-1	26.4	.6
2	14.9	9.9	2	11.1	.6
3	17.2	11.0	3	29.5	.6
4	23.9	0	4	22.2	.6
5	22.5	.6	5	[1] 26.0	------
Average	22.5	5.2	Average	[2] 22.3	[2] .6
38-1	39.7	7.0	52-1	2.8	0
2	9.9	1.2	2	4.1	0
3	14.8	5.1	3	18.0	.3
4	[1] 29.2	------	4	17.3	.6
5	38.1	2.3	5	15.6	.6
Average	[2] 25.6	[2] 3.9	Average	11.6	.3
39-1	1.5	0	53-1	15.6	.9
2	0	0	2	0	0
3	0	0	3	3.2	0
4	0	0	4	2.1	0
5	1.4	0	5	5.0	0
Average	.6	0	Average	5.2	.2
40-1	13.8	3.0	54-1	8.3	0
2	11.9	0	2	24.7	1.2
3	1.9	.6	3	0	0
4	12.5	0	4	15.2	0
5	1.7	0	5	16.2	0
Average	8.4	.7	Average	12.9	.2
41-1	23.2	.6	55-1	13.8	0
2	19.4	3.9	2	5.3	0
3	5.1	0	3	6.2	0
4	18.4	0	4	29.0	.6
5	3.6	0	5	5.1	0
Average	13.9	.9	Average	11.9	.1
42-1	31.2	9.7	56-1	23.6	.6
2	40.5	2.4	2	48.3	1.2
3	13.5	.6	3	18.1	.9
4	25.1	3.0	4	35.6	.6
5	15.2	0	5	28.2	.6
Average	25.1	3.1	Average	30.8	.8

[1] Not included in average. Slab not tested.

[2] Average of 4 values.

133007—37——2

TABLE 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
57-1	3.4	0	71-1	25.1	3.9
2	26.6	2.1	2	5.6	0
3	44.1	------	3	8.8	0
4	32.6	1.4	4	10.0	.6
5	18.2	0	5	27.1	1.2
Average	[2] 20.2	[2] .9	Average	15.3	1.1
58-1	54.2	2.1	72-1	55.0	2.7
2	25.6	.9	2	17.2	1.5
3	15.6	0	3	6.0	0
4	13.4	0	4	9.3	0
5	32.2	.6	5	40.5	2.0
Average	28.2	.7	Average	25.6	1.2
59-1	2.1	0	73-1	19.4	2.0
2	10.2	0	2	7.9	0
3	6.5	0	3	0	0
4	3.2	0	4	3.3	0
5	18.3	0	5	10.2	.6
Average	8.1	0	Average	8.2	.5
60-1	16.2	.6	74-1	9.5	.3
2	4.0	0	2	8.1	0
3	11.6	0	3	18.7	1.7
4	3.7	0	4	11.7	0
5	7.1	0	5	11.6	0
Average	8.5	.1	Average	11.9	.4
61-1	13.8	.6	75-1	47.9	1.8
2	30.6	.6	2	8.1	0
3	10.4	.6	3	0	0
4	24.1	1.4	4	.7	0
5	39.0	3.4	5	42.3	3.9
Average	23.6	1.3	Average	19.8	1.1
62-1	7.2	0	76-1	47.7	4.6
2	12.0	.6	2	9.8	1.5
3	29.7	.6	3	0	0
4	16.2	0	4	25.6	.6
5	15.2	0	5	42.9	1.7
Average	16.1	.2	Average	25.2	1.7
63-1	62.4	4.4	77-1	11.8	.6
2	74.0	2.9	2	5.1	0
3	17.6	.6	3	12.3	0
4	22.6	.6	4	3.8	0
5	36.0	1.2	5	17.2	.6
Average	42.5	1.9	Average	10.0	.2
64-1	3.8	0	78-1	12.9	.6
2	2.9	0	2	2.8	0
3	7.6	0	3	.7	0
4	24.7	.6	4	7.5	0
5	9.8	0	5	8.5	0
Average	9.8	.1	Average	6.5	.1
65-1	14.9	0	79-1	9.8	.9
2	10.2	.6	2	12.8	0
3	2.0	0	3	.6	0
4	7.9	0	4	8.9	0
5	41.7	.6	5	0	0
Average	15.3	.2	Average	6.4	.2
66-1	1.0	0	80-1	14.6	0
2	1.6	0	2	0	0
3	.8	0	3	0	0
4	.8	0	4	3.7	0
5	4.3	0	5	0	0
Average	1.7	0	Average	3.7	0
67-1	4.7	0	81-1	37.6	1.7
2	0	0	2	0	0
3	3.3	0	3	8.8	0
4	2.4	0	4	6.9	0
5	1.5	0	5	12.1	0
Average	2.4	0	Average	13.1	.3
68-1	0	0	82-1	38.2	.6
2	3.4	0	2	4.6	.3
3	0	0	3	0	0
4	6.3	0	4	0	0
5	25.0	.6	5	21.5	1.2
Average	6.9	.1	Average	12.9	.4
69-1	0	0	83-1	3.6	.6
2	0	0	2	4.0	0
3	0	0	3	0	0
4	0	0	4	3.5	0
5	4.9	0	5	11.0	.6
Average	1.0	0	Average	4.4	.2
70-1	15.6	.6	84-1	21.9	.7
2	10.9	0	2	0	0
3	0	0	3	0	0
4	21.7	0	4	4.9	0
5	26.5	.6	5	11.7	.3
Average	14.9	.2	Average	7.7	.4

[1] Not included in average. Slab not tested.

TABLE 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
85-1	38.3	6.4	99-1	8.3	2.9
2	0	0	2	0	0
3	0	0	3	0	0
4	0	0	4	0	0
5	0	0	5	2.3	0
Average	7.7	1.3	Average	2.1	.6
86-1	18.8	.6	100-1	39.0	14.1
2	0	0	2	5.6	0
3	0	0	3	0	0
4	2.2	0	4	3.8	0
5	7.5	.6	5	48.3	7.6
Average	5.7	.2	Average	19.3	4.3
87-1	4.6	0	101-1	4.0	0
2	0	0	2	0	0
3	0	0	3	0	0
4	0	0	4	0	0
5	8.6	0	5	9.6	1.8
Average	2.6	0	Average	2.7	.4
88-1	33.6	3.9	102-1	60.0	10.0
2	3.1	0	2	31.7	4.0
3	0	0	3	16.9	0
4	6.2	.6	4	28.1	4.9
5	23.1	1.5	5	62.6	10.7
Average	13.2	1.2	Average	39.9	5.9
89-1	0	0	103-1	28.3	1.1
2	0	0	2	18.4	1.5
3	0	0	3	0	0
4	0	0	4	13.3	0
5	0	0	5	66.5	9.1
Average	0	0	Average	25.3	2.3
90-1	12.2	3.0	104-1	8.8	1.2
2	0	0	2	0	0
3	0	0	3	0	0
4	.8	0	4	0	0
5	26.5	2.3	5	14.5	0
Average	7.9	1.1	Average	4.7	.2
91-1	0	0	105-1	30.1	5.7
2	0	0	2	0	0
3	0	0	3	0	0
4	0	0	4	4.4	.8
5	0	0	5	13.5	0
Average	0	0	Average	9.6	1.3
92-1	0	0	106-1	[1] 62.2	[1] 7.9
2	0	0	2	8.8	0
3	0	0	3	0	0
4	0	0	4	8.5	1.1
5	1.7	0	5	38.5	4.2
Average	.3	0	Average	[2] 14.0	[2] 1.3
93-1	3.3	.6	107-1	14.0	1.2
2	0	0	2	6.7	0
3	0	0	3	6.5	0
4	0	0	4	7.1	.6
5	0	0	5	7.1	.6
Average	.7	.1	Average	8.3	.5
94-1	28.0	6.4	108-1	24.4	2.9
2	16.8	3.3	2	0	0
3	0	0	3	0	0
4	8.6	.6	4	0	0
5	60.0	5.2	5	26.7	2.1
Average	22.7	3.1	Average	10.2	1.0
95-1	7.0	0	109-1	2.6	0
2	0	0	2	0	0
3	0	0	3	0	0
4	0	0	4	0	0
5	3.3	0	5	0	0
Average	2.1	0	Average	.5	0
96-1	31.7	10.3	110-1	0	0
2	0	0	2	0	0
3	0	0	3	0	0
4	14.9	1.3	4	0	0
5	15.4	5.6	5	0	0
Average	12.4	3.4	Average	0	0
97-1	25.9	5.6	111-1	0	0
2	4.5	1.7	2	2.8	0
3	0	0	3	0	0
4	0	0	4	0	0
5	21.5	1.9	5	6.9	0
Average	10.4	1.8	Average	1.9	0
98-1	14.4	3.5	112-1	5.3	1.2
2	0	0	2	3.7	0
3	0	0	3	0	0
4	0	0	4	6.1	0
5	3.5	.7	5	11.6	.3
Average	3.6	.8	Average	5.2	.3

[2] Average of 4 values.

TABLE 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb Bottom	Honeycomb Break	Slab no.	Honeycomb Bottom	Honeycomb Break
	Percent	*Percent*		*Percent*	*Percent*
113-1	25.1	1.2	127-1	6.5	0
2	5.8	0	2	0	0
3	0	0	3	0	0
4	0	0	4	1.1	0
5	19.7	.6	5	17.1	.9
Average	10.1	.4	Average	4.9	.2
114-1	69.9	7.1	128-1	31.8	1.2
2	11.4	0	2	3.1	.6
3	2.8	0	3	1.6	0
4	15.6	2.1	4	.9	0
5	32.6	2.4	5	48.7	3.3
Average	26.5	2.3	Average	17.2	1.0
115-1	17.9	1.2	129-1	4.8	0
2	20.3	.6	2	1.0	0
3	0	0	3	6.1	0
4	3.0	.6	4	2.6	0
5	13.3	0	5	16.8	.3
Average	10.9	.5	Average	6.3	.1
116-1	3.8	0	130-1	7.3	.3
2	3.5	.3	2	4.9	2.3
3	3.8	0	3	5.8	.6
4	0	0	4	0	0
5	2.8	0	5	3.7	0
Average	2.8	.1	Average	4.3	.6
117-1	41.3	1.7	131-1	.6	0
2	22.0	.6	2	3.2	0
3	0	0	3	2.0	0
4	10.6	.6	4	0	0
5	15.7	.6	5	2.8	0
Average	17.9	.7	Average	1.7	0
118-1	2.3	0	132-1	0	0
2	8.1	0	2	12.6	.9
3	0	0	3	8.3	.6
4	4.4	0	4	2.6	0
5	22.7	0	5	3.4	0
Average	7.5	0	Average	5.4	.3
119-1	22.5	.6	133-1	15.2	.6
2	6.5	0	2	15.1	3.4
3	0	0	3	5.9	.6
4	12.8	.6	4	9.8	0
5	30.5	2.4	5	15.1	1.7
Average	14.5	.7	Average	12.2	1.3
120-1	8.8	.6	134-1	35.9	2.0
2	4.1	0	2	9.1	0
3	5.8	1.5	3	14.0	0
4	9.4	1.4	4	23.0	0
5	6.7	.6	5	22.2	.3
Average	7.0	.8	Average	20.8	.5
121-1	35.3	.6	135-1	1.2	0
2	8.4	0	2	0	0
3	.6	0	3	0	0
4	4.6	0	4	1.5	0
5	56.6	4.4	5	3.0	0
Average	21.1	1.0	Average	1.1	0
122-1	6.6	.6	136-1	1.3	0
2	2.2	.6	2	2.6	0
3	1.8	0	3	0	0
4	0	0	4	5.0	.3
5	6.7	.6	5	6.1	0
Average	3.5	.4	Average	3.0	.1
123-1	3.3	0	137-1	5.1	.3
2	5.8	0	2	0	0
3	0	0	3	0	0
4	0	0	4	9.4	.6
5	2.1	0	5	20.3	.9
Average	2.2	0	Average	7.0	.4
124-1	14.3	.9	138-1	33.3	2.6
2	0	0	2	2.3	0
3	0	0	3	0	0
4	10.2	.3	4	13.9	.3
5	15.0	.6	5	22.1	.6
Average	7.9	.4	Average	14.3	.7
125-1	2.8	0	139-1	4.0	2.3
2	1.1	0	2	2.2	0
3	3.2	0	3	8.5	0
4	0	0	4	5.6	0
5	6.5	0	5	6.6	0
Average	2.7	0	Average	5.4	.5
126-1	8.1	.9	140-1	20.1	2.7
2	9.8	0	2	1.2	0
3	0	0	3	.9	.3
4	3.8	0	4	3.7	0
5	66.3	3.1	5	45.5	4.1
Average	17.6	.8	Average	14.3	1.4

TABLE 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb Bottom	Honeycomb Break	Slab no.	Honeycomb Bottom	Honeycomb Break
	Percent	*Percent*		*Percent*	*Percent*
141-1	16.5	1.5	155-1	10.5	0
2	4.4	0	2	1.4	0
3	0	0	3	0	0
4	6.8	.3	4	9.7	0
5	21.9	.3	5	50.9	3.3
Average	9.9	.4	Average	14.5	.7
142-1	4.8	0	156-1	16.7	2.4
2	7.1	0	2	15.6	4.2
3	3.1	0	3	1.4	0
4	9.8	.3	4	9.6	.3
5	1.0	0	5	85.2	7.2
Average	5.2	.1	Average	25.7	2.8
143-1	9.8	.6	157-1	25.8	.6
2	0	0	2	2.6	.3
3	12.1	0	3	1.0	0
4	6.2	.3	4	3.0	0
5	6.0	6.2	5	3.8	0
Average	6.8	1.4	Average	7.2	.2
144-1	8.5	0	158-1	64.9	6.8
2	0	0	2	23.3	.9
3	0	0	3	0	0
4	5.4	.6	4	25.7	1.8
5	30.9	3.8	5	75.5	6.5
Average	9.0	.9	Average	37.9	3.2
145-1	19.0	0	159-1	2.6	0
2	0	0	2	0	0
3	.9	0	3	0	0
4	1.6	0	4	0	0
5	17.5	.3	5	0	0
Average	7.8	.1	Average	.5	0
146-1	73.3	5.2	160-1	0	0
2	5.3	0	2	0	0
3	1.4	0	3	0	0
4	36.2	.9	4	.6	0
5	75.5	8.6	5	1.5	0
Average	38.3	2.9	Average	.4	0
147-1	4.9	.9	161-1	3.8	0
2	0	0	2	3.3	0
3	0	0	3	0	0
4	2 8	0	4	4.7	0
5	6.9	0	5	1.2	0
Average	2.9	.2	Average	2.6	0
148-1	.8	0	162-1	27.1	3.5
2	0	0	2	23.1	2.4
3	0	0	3	0	0
4	2.2	0	4	6.0	0
5	0	0	5	29.0	1.7
Average	.6	0	Average	17.0	1.5
149-1	14.7	.3	163-1	4.9	.9
2	3.4	0	2	0	0
3	0	0	3	0	0
4	5.8	0	4	15.6	0
5	.7	0	5	5.7	0
Average	4.9	.1	Average	5.2	.2
150-1	23.0	0	164-1	44.8	0.9
2	6.1	0	2	5.8	0
3	0	0	3	2.8	0
4	5.0	0	4	9.4	.6
5	25.3	.9	5	60.0	2.9
Average	11.9	.2	Average	24.6	.9
151-1	20.8	0	165-1	0	0
2	0	0	2	0	0
3	1.0	0	3	0	0
4	7.0	0	4	6.9	0
5	9.0	.6	5	7.8	0
Average	7.6	.1	Average	2.9	0
152-1	62.2	6.4	166-1	3.7	0
2	4.3	.3	2	0	0
3	5.3	.6	3	0	0
4	22.5	3.7	4	2.1	0
5	55.1	4.3	5	28.9	.3
Average	29.9	3.1	Average	6.9	.1
153-1	7.6	.6	167-1	6.3	0
2	1.2	0	2	4.6	0
3	0	0	3	0	0
4	2.2	0	4	1.9	0
5	28.0	4.5	5	16.0	.6
Average	7.8	1.0	Average	5.8	.1
154-1	.3	0	168-1	2.6	.3
2	.8	0	2	3.2	0
3	.8	0	3	1.4	0
4	0	0	4	1.0	0
5	3.1	0	5	3.2	0
Average	1.0	0	Average	2.3	.1

Table 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
169-1	19.6	0.9	184-1	100.0	19.1
2	.9	0	2	53.5	3.1
3	0	0	3	29.7	0
4	17.1	0	4	53.9	12.9
5	.5	0	5	100.0	12.1
Average	7.6	.2	Average	67.4	9.4
170-1	1.4	0	185-1	2.4	0
2	0	0	2	.6	0
3	0	0	3	0	0
4	0	0	4	25.8	.9
5	18.5	0	5	35.7	1.2
Average	4.0	0	Average	12.9	.4
171-1	34.6	4.2	186-1	10.0	.9
2	1.0	0	2	1.1	0
3	0	0	3	1.2	0
4	13.3	0	4	35.1	2.7
5	68.3	.9	5	29.4	.6
Average	23.4	1.0	Average	15.4	.8
172-1	0	0	187-1	38.0	3.0
2	0	0	2	24.4	.6
3	0	0	3	37.4	2.1
4	0	0	4	100.0	8.0
5	0	0	5	63.5	5.6
Average	0	0	Average	52.7	3.9
173-1	2.0	0	188-1	10.1	.6
2	0	0	2	2.3	0
3	0	0	3	3.2	0
4	0	0	4	37.2	2.0
5	.8	0	5	27.4	.9
Average	.6	0	Average	16.0	.7
174-1	22.0	.6	189-1	33.8	.3
2	4.2	0	2	9.8	.6
3	0	0	3	17.6	.6
4	15.9	0	4	81.5	3.9
5	36.1	.9	5	68.1	3.2
Average	15.6	.3	Average	42.2	1.7
175-1	2.4	0	190-1	21.1	.9
2	3.6	.3	2	8.1	.6
3	1.1	0	3	5.6	.9
4	1.7	0	4	5.7	0
5	14.6	.6	5	19.5	.6
Average	4.7	.2	Average	12.0	.6
176-1	12.5	0	191-1	67.5	4.6
2	6.5	0	2	4.4	0
3	0	0	3	5.0	0
4	10.2	.3	4	31.8	1.8
5	34.9	1.2	5	95.3	4.8
Average	12.8	.3	Average	40.8	2.2
177-1	7.2	.9	192-1	6.1	0
2	11.7	0	2	29.8	3.0
3	3.1	0	3	0	0
4	8.2	0	4	4.4	.3
5	3.5	0	5	3.5	0
Average	6.7	.2	Average	8.8	.7
178-1	32.4	13.0	193-1	4.1	0
2	12.5	3.7	2	35.3	1.7
3	0	0	3	2.4	0
4	21.7	5.1	4	1.9	0
5	40.6	4.0	5	3.8	0
Average	21.4	5.2	Average	9.5	.3
179-1	1.7	0	194-1	11.2	0
2	0	0	2	4.0	0
3	0	0	3	0	0
4	2.3	0	4	28.3	1.8
5	5.8	.9	5	36.1	2.1
Average	2.0	.2	Average	15.9	.8
180-1	3.9	.8	195-1	8.9	0
2	5.7	0	2	1.9	0
3	9.8	0	3	4.3	0
4	3.1	0	4	2.9	0
5	.8	0	5	15.2	.6
Average	4.7	.2	Average	6.6	.1
181-1	13.3	0	196-1	25.1	2.0
2	3.8	0	2	4.2	.3
3	1.6	0	3	0	0
4	3.5	0	4	35.1	1.7
5	9.0	0	5	42.7	2.4
Average	6.2	0	Average	21.4	1.3
182-1	15.8	2.4	197-1	45.4	2.7
2	4.8	0	2	9.0	0
3	1.2	0	3	1.5	0
4	16.8	.6	4	30.3	3.4
5	23.5	0	5	18.3	.3
Average	12.4	.6	Average	20.9	1.3
183-1	19.0	.9	198-1	34.0	.9
2	8.1	0	2	7.1	.6
3	2.1	0	3	4.0	0
4	2.0	0	4	22.4	.6
5	27.6	3.3	5	84.7	3.2
Average	11.8	.8	Average	30.4	1.1

Table 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
199-1	3.4	0	214-1	24.6	1.2
2	1.3	0	2	17.2	.6
3	0	0	3	10.3	1.5
4	2.2	0	4	26.5	1.6
5	4.4	0	5	19.4	1.6
Average	2.3	0	Average	19.6	1.3
200-1	4.1	0	215-1	16.9	2.0
2	17.3	2.0	2	7.2	0
3	0	0	3	12.5	0
4	10.0	0	4	17.5	0
5	0	0	5	3.1	0
Average	6.3	.4	Average	11.4	.4
201-1	1.4	0	216-1	96.1	15.5
2	14.1	0	2	64.7	1.7
3	13.4	.9	3	64.9	2.3
4	6.8	1.5	4	77.5	3.7
5	7.8	0	5	51.4	6.1
Average	8.7	.5	Average	70.9	5.9
202-1	9.7	.6	217-1	14.3	.9
2	10.1	1.4	2	15.5	.6
3	19.0	2.3	3	1.0	0
4	12.8	.9	4	19.4	0
5	7.1	.6	5	21.2	.3
Average	11.7	1.2	Average	14.3	.4
203-1	17.0	.4	218-1	4.2	0
2	0	0	2	17.6	.6
3	0	0	3	2.2	0
4	0	0	4	5.2	0
5	26.2	.4	5	22.6	.6
Average	8.6	.2	Average	10.4	.2
204-1	73.2	9.0	219-1	14.4	0
2	17.6	.4	2	6.0	0
3	3.7	0	3	0	0
4	25.0	.8	4	9.1	.6
5	76.3	9.2	5	13.8	0
Average	39.2	3.9	Average	8.7	.1
205-1	0	0	220-1	32.1	1.2
2	0	0	2	11.9	0
3	0	0	3	0	0
4	11.3	0	4	27.4	.6
5	13.1	0	5	30.4	2.0
Average	4.9	0	Average	20.4	.8
206-1	0	0	221-1	12.3	.6
2	0	0	2	10.8	0
3	.8	0	3	4.5	1.5
4	1.5	0	4	25.4	1.2
5	0	0	5	26.5	1.5
Average	.5	0	Average	15.9	1.0
207-1	0	0	222-1	77.4	4.9
2	0	0	2	14.6	1.8
3	0	0	3	14.4	.6
4	0	0	4	18.4	2.1
5	11.5	0	5	46.8	3.6
Average	2.3	0	Average	34.3	2.6
208-1	3.8	0	223-1	12.2	0
2	2.5	0	2	5.9	0
3	5.2	0	3	9.7	.9
4	11.8	0	4	16.2	0
5	14.2	0	5	7.7	0
Average	7.5	0	Average	10.3	.2
209-1	8.6	.9	224-1	4.9	.3
2	16.9	1.4	2	13.0	0
3	9.2	0	3	4.6	0
4	11.0	.3	4	14.4	.6
5	14.1	1.5	5	4.9	.9
Average	12.0	.8	Average	8.4	.4
210-1	50.5	3.9	225-1	6.1	0
2	7.6	.8	2	3.3	0
3	28.3	.3	3	1.9	0
4	15.1	.5	4	10.3	.6
5	72.0	4.3	5	16.8	0
Average	34.7	2.0	Average	7.7	.1
211-1	12.2	1.4	226-1	20.6	.9
2	5.2	.3	2	18.0	1.2
3	9.6	1.7	3	3.9	0
4	9.2	.3	4	24.6	.9
5	4.4	.3	5	53.1	3.4
Average	8.1	.8	Average	24.0	1.3
212-1	6.0	.9	227-1	31.7	2.4
2	9.2	.6	2	8.1	0
3	12.8	1.2	3	19.2	.9
4	10.4	1.5	4	0	0
5	3.5	.5	5	21.6	3.3
Average	8.4	.9	Average	16.1	1.3
213-1	14.4	.9	228-1	49.2	4.4
2	4.2	.3	2	12.3	0
3	12.6	1.8	3	2.0	0
4	19.4	2.4	4	5.0	0
5	11.2	.8	5	48.7	2.3
Average	12.4	1.2	Average	23.4	1.3

TABLE 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
229–1	12.2	0	244–1	5.7	0
2	1.4	0	2	24.6	.6
3	9.2	0	3	7.1	0
4	4.4	1.2	4	36.4	.3
5	4.0	1.2	5	30.1	.6
Average	6.2	.5	Average	20.8	.3
230–1	3.3	0	245–1	46.3	2.1
2	6.9	0	2	2.6	.2
3	20.0	1.2	3	1.6	0
4	4.1	0	4	13.3	.2
5	.6	0	5	42.9	3.2
Average	7.0	.2	Average	21.3	1.1
231–1	5.4	0	246–1	0	0
2	6.7	.9	2	0	0
3	19.5	1.2	3	1.8	0
4	10.6	0	4	0	0
5	1.4	0	5	0	0
Average	8.7	.4	Average	.4	0
232–1	8.2	.6	247–1	30.8	3.5
2	4.9	0	2	1.7	0
3	59.1	2.4	3	0	0
4	48.0	1.7	4	0	0
5	30.4	.9	5	20.3	.6
Average	30.1	1.1	Average	10.6	.8
233–1	17.5	.6	248–1	0	0
2	19.6	1.7	2	0	0
3	4.7	.3	3	0	0
4	10.8	0	4	0	0
5	42.8	4.7	5	0	0
Average	19.1	1.5	Average	0	0
234–1	89.0	6.1	249–1	1.6	0
2	45.7	1.2	2	0	0
3	40.3	.6	3	0	0
4	70.4	5.3	4	0	0
5	90.0	8.3	5	25.6	.2
Average	67.1	4.3	Average	5.4	0
235–1	5.3	.3	250–1	0	0
2	4.0	0	2	4.2	0
3	1.1	0	3	1.2	0
4	22.6	.3	4	1.2	0
5	21.5	.3	5	24.9	.6
Average	10.9	.2	Average	6.3	.1
236–1	4.2	0	251–1	14.0	.3
2	2.8	0	2	0	0
3	6.1	0	3	0	0
4	14.8	.3	4	0	0
5	23.5	.9	5	2.2	0
Average	10.3	.2	Average	3.2	.1
237–1	32.6	.9	252–1	48.7	8.4
2	25.1	.6	2	24.4	6.0
3	7.2	0	3	1.9	0
4	12.3	0	4	17.1	2.9
5	13.2	0	5	49.3	7.4
Average	18.1	.3	Average	28.3	4.9
238–1	39.8	1.8	253–1	5.3	0
2	40.1	2.4	2	22.0	0
3	14.0	0	3	1.4	0
4	35.3	.6	4	0	0
5	46.9	2.6	5	0	0
Average	35.2	1.5	Average	5.7	0
239–1	22.9	2.9	254–1	5.3	0
2	11.8	0	2	11.6	.6
3	3.6	0	3	2.4	0
4	8.2	.8	4	5.3	0
5	24.4	3.2	5	52.3	.9
Average	14.2	1.4	Average	15.4	.3
240–1	91.1	11.8	255–1	14.4	0
2	41.5	9.4	2	4.0	0
3	15.3	0	3	10.3	0
4	40.9	7.9	4	15.7	0
5	95.3	13.0	5	20.8	.3
Average	56.8	8.4	Average	13.0	.1
241–1	6.2	0	256–1	55.7	3.7
2	5.3	0	2	24.6	2.4
3	1.7	0	3	10.3	.6
4	21.9	.3	4	38.9	3.9
5	17.7	.6	5	88.0	8.5
Average	10.6	.2	Average	43.5	3.8
242–1	3.5	0	257–1	20.5	2.4
2	4.6	0	2	18.5	1.2
3	4.3	0	3	6.7	0
4	13.7	0	4	30.8	.9
5	3.3	0	5	63.9	5.7
Average	5.9	0	Average	28.1	2.0
243–1	5.2	.3	258–1	81.1	14.5
2	4.5	0	2	63.3	5.5
3	1.7	0	3	31.3	1.2
4	21.9	.6	4	54.9	8.2
5	10.9	.6	5	100.0	14.9
Average	8.8	.3	Average	66.1	8.9

TABLE 5.—*Percentage of honeycomb in slabs*—Continued

Slab no.	Honeycomb		Slab no.	Honeycomb	
	Bottom	Break		Bottom	Break
	Percent	*Percent*		*Percent*	*Percent*
259–1	13.2	0	265–1	18.5	0.6
2	15.2	0	2	17.3	2.0
3	23.3	1.2	3	0	0
4	8.2	0	4	1.5	0
5	15.1	0	5	55.3	4.2
Average	15.0	.2	Average	18.5	1.4
260–1	26.6	.9	266–1	7.4	0
2	3.4	0	2	0	0
3	10.6	0	3	0	0
4	17.2	.9	4	0	0
5	39.6	.6	5	11.1	0
Average	19.5	.5	Average	3.7	0
261–1	0	0	267–1	0	0
2	0	0	2	0	0
3	0	0	3	0	0
4	0	0	4	0	0
5	0	0	5	0	0
Average	0	0	Average	0	0
262–1	5.3	0	268–1	4.5	0
2	0	0	2	1.6	0
3	0	0	3	0	0
4	0	0	4	.6	0
5	9.4	0	5	6.4	0
Average	2.9	0	Average	2.6	0
263–1	2.6	0	269–1	8.3	0
2	0	0	2	4.9	0
3	0	0	3	0	0
4	0	0	4	0	0
5	1.2	0	5	1.3	0
Average	.8	0	Average	2.9	0
264–1	11.8	.9	270–1	0	0
2	7.8	.6	2	0	0
3	0	0	3	0	0
4	6.4	.6	4	6.0	.6
5	20.6	.9	5	10.6	2.3
Average	9.3	.6	Average	3.3	.6

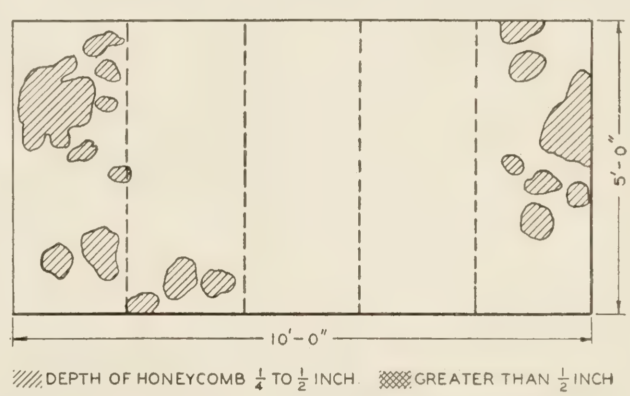


FIGURE 2.—DISTRIBUTION OF HONEYCOMB AT BOTTOM OF A SECTION (SERIES B) HAVING: BASE MIX; STANDARD FINISH; A SLUMP OF 2.5 INCHES; AND 10.1 PERCENT HONEYCOMB.

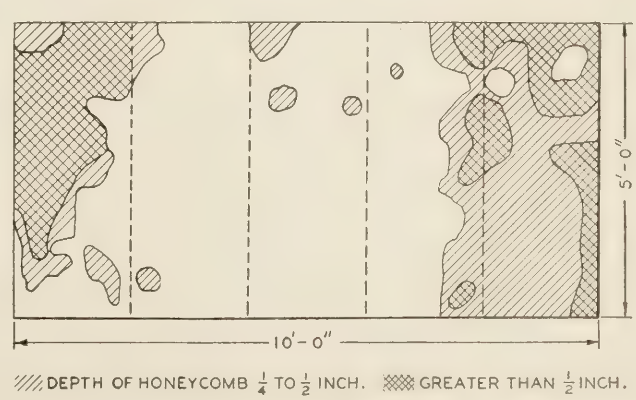


FIGURE 3.—DISTRIBUTION OF HONEYCOMB AT BOTTOM OF A SECTION (SERIES B) HAVING: BASE MIX; STANDARD FINISH; A SLUMP OF 1.2 INCHES; AND 40.8 PERCENT HONEYCOMB.

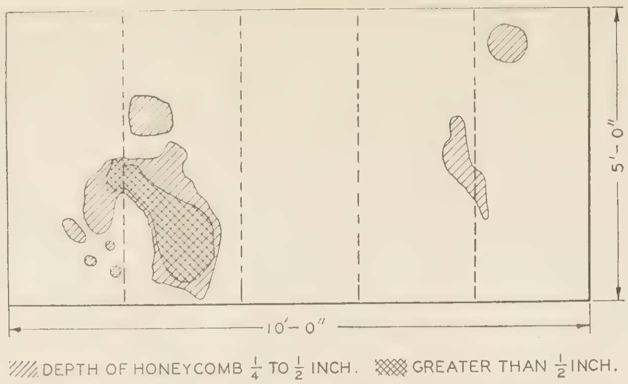


FIGURE 4.—DISTRIBUTION OF HONEYCOMB AT BOTTOM OF A SECTION (SERIES B) HAVING: BASE MIX; VIBRATED; A SLUMP OF 1.2 INCHES; AND 8.8 PERCENT HONEYCOMB.

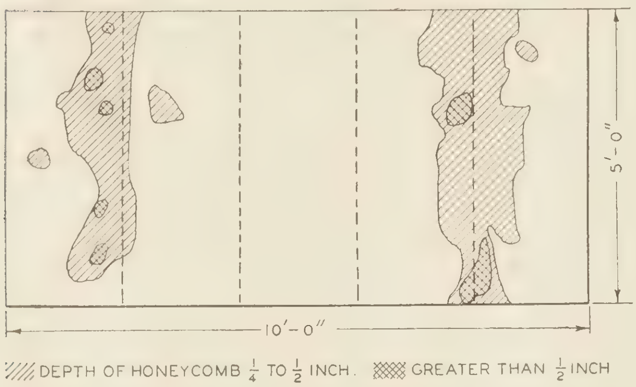


FIGURE 5.—DISTRIBUTION OF HONEYCOMB AT BOTTOM OF A SECTION (SERIES B) HAVING: ONE PART OF COARSE AGGREGATE ADDED TO BASE MIX; VIBRATED; A SLUMP OF 0.8 INCH; AND 20.4 PERCENT HONEYCOMB.

TABLE 6.—*Results of strength tests*

Section no.	Modulus of rupture [1] at age of 9½ months		Crushing strength [2] at age of 14 months	
	Pavement slabs	Control beams	Pavement cores	Control cylinders
	Lb. per sq. in.	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*
1-S [3]	707	579	7,340	4,900
2-S	695	650	6,400	5,390
3-V	682		7,820	6,320
4-V	643		6,910	5,380
5-V	696		7,270	5,540
6-V	642		7,430	5,340
7-S	685	571	7,820	5,480
8-S	688	628	8,050	6,150
9-V	711		8,450	6,130
10-V	673		6,880	5,280
11-V	[4] 674		6,620	5,180
12-V	[4] 599		6,920	5,090
13-S	663	637	7,360	5,900
14-S	655	630	7,930	6,030
15-V	594		7,540	6,570
16-V	647		7,840	6,370
17-V	[4] 661		8,080	5,420
18-V	575		6,800	5,990
19-S	656	594	6,150	5,760
20-S	637	639	8,360	5,800
21-V	681		8,080	6,000
22-V	695		6,920	5,890
23-V	692		7,590	5,590
24-V	656		7,100	5,960
25-S	686	681	8,410	5,890
26-S	602	669	8,030	6,390
27-V	750		8,300	6,150
28-V	712		8,180	6,440
29-V	715		7,880	5,680
30-V	712		7,450	5,980
31-S	881	741	7,760	6,470
32-S	886	834	8,700	6,600
33-V	998		8,880	6,510
34-V	884		8,060	6,190
35-V	868		8,400	6,360
36-V	852		8,350	6,090
37-S	836	720	7,170	6,640
38-S	[4] 876	807	7,540	6,570
39-V	989		8,130	6,790
40-V	[4] 952		8,520	7,080
41-V	848		8,140	6,780
42-V	798		7,580	6,720
43-S	896	720	7,400	6,280
44-S	[4] 918	755	7,830	6,850
45-V	898		7,580	6,650
46-V	887		7,600	6,620
47-V	927		8,260	6,980
48-V	931		8,320	6,860
49-V	[4] 973		7,800	6,930
50-S	894	689	7,060	6,000
51-S	[4] 913	685	7,480	6,260
52-V	916		7,880	6,500
53-V	973		8,060	6,070
54-V	921		8,280	6,740
55-V	885		7,200	6,290
56-V	[4] 877		8,020	6,510
57-S	[4] 672	659	6,760	5,480
58-S	752	657	7,460	5,870
59-V	770		8,330	6,330
60-V	765		7,170	6,670
61-V	691		7,660	6,140
62-V	698		7,890	6,170
63-V	733		7,920	6,490
64-S	726	622	7,180	5,420
65-S	745	658	7,180	5,730
66-V	763		7,630	6,190
67-V	746		7,900	5,870
68-V	754		7,620	6,370
69-V	756		6,980	6,250
70-V	702		7,400	6,280
71-S	674	592	6,680	5,230
72-S	720	617	7,720	5,960
73-V	698		7,920	5,870
74-V	658		7,120	5,560
75-V	667		6,560	5,480
76-V	668		6,520	5,390
77-S	703	600	6,380	5,070
78-S	698	627	7,330	5,860
79-V	712		7,190	6,130
80-V	662		6,500	4,920
81-V	693		6,860	5,170
82-V	675		6,160	4,930
83-S	665	588	7,140	5,090
84-S	734	603	6,730	5,910
85-V	701	[5] 616	7,440	5,840
86-V	672		6,040	4,930
87-V	609		6,420	5,030
88-V	639		6,420	5,350
89-S	[4] 794	704	6,620	5,780
90-S	817	712	6,600	6,260
91-V	812		6,600	6,190
92-V	767		7,030	5,910
93-V	814		6,450	5,910
94-V	781		6,340	5,650
95-S	679	732	5,780	5,830
96-S	714	730	6,260	6,650
97-V	768		6,210	6,320
98-V	732		6,460	5,640
99-V	722		6,680	5,370
100-V	716		6,700	5,900
101-S	554	602	5,660	5,830
102-S	558	626	6,160	5,960
103-V	628		6,440	6,130
104-V	609		5,800	5,580
105-V	596		5,850	5,310
106-V	[4] 583		6,270	5,100
107-S	662	572	6,560	5,490
108-S	686	661	6,990	6,140
109-V	715		7,330	5,980
110-V	667		6,500	5,310
111-V	668		6,410	5,250
112-V	598		5,860	4,750
113-S	640	533	7,050	5,510
114-S	675	652	6,240	5,830
115-V	732		7,150	5,890
116-V	715		7,320	5,520
117-V	691		7,490	5,680
118-V	719		7,140	6,190
119-V	742		6,780	6,640
120-S	671	611	6,680	5,610
121-S	738	619	7,350	5,930
122-V	745		7,640	6,090
123-V	698		7,280	6,100
124-V	741		7,880	6,600
125-V	726		7,680	5,590
126-V	737		7,520	6,450
127-S	662	579	6,260	5,160
128-S	659	633	6,840	5,950
129-V	719		7,240	5,920
130-V	656		6,300	5,360
131-V	688		6,620	5,210

[1] All slab values are the average of 5 tests unless otherwise noted. All beam values are the average of 4 tests unless otherwise noted.
[2] All core values are the average of 2 tests unless otherwise noted. All cylinder values are the average of 3 tests unless otherwise noted.
[3] Symbols used indicate: S-Standard finish. V-Vibrated finish.
[4] Average of less than 5 tests.
[5] Average of 3 tests.

TABLE 6.—*Results of strength tests*—Continued

Section no.	Modulus of rupture at age of 9½ months		Crushing strength at age of 14 months	
	Pavement slabs	Control beams	Pavement cores	Control cylinders
	Lb. per sq. in.	*Lb. per sq. in.*	*Lb. per sq. in.*	*Lb. per sq. in.*
132-V	640		6,670	5,600
133-S	668	591	6,220	5,730
134-S	646	576	6,920	6,320
135-V	696		6,740	6,030
136-V	692		6,170	5,570
137-V	668		6,100	5,350
138-V	654		5,730	5,580
139-S	766	638	6,520	5,200
140-S	875	703	6,940	6,210
141-V	841		7,020	6,330
142-V	794		6,660	5,190
143-V	824		6,430	5,600
144-V	823		6,800	5,600
145-S	840	699	7,120	5,630
146-S	864	753	7,940	6,520
147-V	908		7,900	6,430
148-V	823		7,220	6,150
149-V	828		7,340	6,230
150-V	798		6,670	6,090
151-S	868	674	6,280	5,260
152-S	801	[5] 744	7,120	6,160
153-V	863	764	6,530	6,300
154-V	803	717	6,020	5,270
155-V	822	754	6,540	5,670
156-V	773	704	5,620	5,320
157-S	847	730	6,800	5,560
158-S	864	769	7,220	6,540
159-V	929	764	7,040	6,500
160-V	809	693	6,320	5,590
161-V	875	719	6,540	5,440
162-V	853	710	7,200	5,610
163-S	818	748	7,180	5,370
164-S	908	794	7,670	6,770
165-V	873	794	7,200	6,710
166-V	899	792	8,010	6,970
167-V	930	831	7,720	6,860
168-V	915	775	7,660	6,760
169-V	911	796	8,540	7,170
170-S	800	714	6,820	5,810
171-S	822	809	6,960	6,550
172-V	917	786	7,280	6,960
173-V	948	837	7,380	6,920
174-V	981	855	7,600	7,070
175-V	893	784	7,680	7,090
176-V	910	844	7,880	7,540
177-S	831	680	6,900	5,790
178-S	826	708	7,320	6,800
179-V	884	751	7,380	6,760
180-V	842	686	6,870	5,720
181-V	846	698	6,840	5,610
182-V	864	729	6,640	6,040
183-S	678	590	6,460	5,840
184-S	625	672	7,320	6,890
185-V	720	597	7,360	6,760
186-V	714	656	7,400	6,390
187-V	696		7,860	6,900
188-V	718		7,880	6,740
189-V	721		7,980	7,220
190-S	672	612	6,560	4,690
191-S	682	586	6,460	5,600
192-V	712	602	7,360	5,810
193-V	716	628	7,020	5,420
194-V	720	641	8,070	6,510
195-V	715	644	7,420	6,050
196-V	685	634	7,700	6,080
197-S	693	585	5,860	4,910
198-S	750	639	7,070	5,970
199-V	770	597	7,200	5,740
200-V	665	592	6,100	5,090
201-V	669	610	6,620	5,240
202-V	671	638	6,420	4,990
203-S	625	554	5,530	5,430
204-S	604	632	6,150	5,900
205-V	644	608	5,840	5,360
206-V	621	574	6,100	5,270
207-V	605	600	5,580	4,950
208-V	618	589	5,760	5,290
209-S	691	588	7,240	5,190
210-S	703	580	7,060	5,250
211-V	740	573	7,550	5,170
212-V	692	575	6,810	4,880
213-V	721	552	7,000	5,100
214-V	676	585	7,600	5,240
215-S	682	596	7,820	6,230
216-S	655	622	8,000	6,890
217-V	705	600	7,800	7,010
218-V	701	595	7,340	6,100
219-V	653	585	7,080	5,740
220-V	687	591	7,040	5,970
221-S	683	556	7,240	5,840
222-S	668	612	7,550	6,720
223-V	697	587	7,460	6,710
224-V	686	583	7,150	5,650
225-V	690	588	6,860	5,600
226-V	643	578	6,530	5,720
227-S	812	638	7,170	5,230
228-S	861	730	7,740	6,980
229-V	897	728	8,060	6,660
230-V	823	670	7,360	5,910
231-V	864	710	6,830	5,550
232-V	817	705	7,070	5,760
233-S	850	716	7,430	6,140
234-S	836	762	7,860	7,070
235-V	852	800	7,520	7,050
236-V	836	755	7,360	6,600
237-V	829	740	7,580	6,300
238-V	828	722	7,720	5,960
239-S	855	627	7,960	6,120
240-S	806	745	8,020	7,100
241-V	911	739	8,400+	7,470
242-V	852	725	8,130	6,340
243-V	793	710	7,780	6,260
244-V	787	684	7,460	6,010
245-S	739	726	5,800	6,420
246-V	772	728	7,130	6,550
247-S	779	688	6,430	6,140
248-V	843	712	7,140	5,990
249-V	820	734	6,820	6,060
250-V	767	[5] 777	6,780	6,380
251-S	793	673	6,720	6,500
252-S	757	729	7,560	7,400
253-V	778	758	7,140	7,420
254-V	770	754	7,520	6,650
255-S	843	694	6,860	6,520
256-S	837	736	8,080	7,240
257-V	829	769	7,240	6,970
258-V	760	790	7,420	6,810
259-S	776	680	6,580	5,920
260-S	836	708	8,320	6,940
261-V	889	688	6,960	6,520
262-V	853	694	7,180	6,200
263-V	859	673	7,150	6,190
264-V	845	730	7,100	6,470
265-S	851	712	7,400	6,710
266-S	878	639	7,100	6,440
267-V	846	681	7,360	6,810
268-V	847	652	6,760	6,480
269-V	829	695	6,850	6,180
270-V	783	678	7,140	6,350

[5] Average of 3 tests.

TABLE 7.—*Specific gravity and absorption of concrete slabs*

Section no.	Specific gravity of slab no.				Absorption of slab no.			
	1	3	5	Average	1	3	5	Average
					Percent	*Percent*	*Percent*	*Percent*
1	2.32	2.31	2.31	2.31	5.41	5.93	5.97	5.77
2	2.31	2.30	2.31	2.31	5.89	5.84	5.99	5.91
3	2.31	2.35	2.33	2.33	5.26	4.78	5.19	5.08
4	2.34	2.32	2.36	2.34	5.25	5.64	4.95	5.28
5	2.33	2.30	2.34	2.32	5.35	5.71	4.97	5.34
6	2.37	2.32	2.37	2.36	4.42	5.47	4.58	4.82
7	2.35	2.33	2.32	2.33	4.89	5.04	5.22	5.05
8	2.33	2.32	2.34	2.33	4.87	5.21	4.83	4.97
9	2.33	2.32	2.32	2.32	4.85	5.09	5.11	5.02
10	2.35	2.33	2.34	2.34	4.92	5.18	4.90	5.00
11	2.34	2.33	2.35	2.34	5.06	5.00	4.79	4.95
12	2.34	2.33	2.36	2.34	5.04	5.01	4.41	4.82
13	2.32	2.33	2.34	2.33	5.28	5.04	4.91	5.08
14	2.33	2.33	2.32	2.33	4.84	5.06	5.29	5.06
15	2.34	2.34	2.38	2.35	4.82	4.49	4.36	4.56
16	2.35	2.33	2.35	2.34	4.52	4.78	4.64	4.65
17	2.36	2.36	2.34	2.35	4.23	4.61	4.66	4.50
18	2.34	2.37	2.36	2.36	4.72	4.21	4.30	4.41
19	2.32	2.33	2.31	2.32	5.07	5.00	5.40	5.16
20	2.34	2.32	2.34	2.33	4.97	5.20	4.94	5.04
21	2.33	2.36	2.36	2.35	4.67	4.33	4.11	4.37
22	2.35	2.35	2.34	2.35	4.52	4.63	4.50	4.55
23	2.37	2.35	2.34	2.35	4.10	4.26	4.64	4.33
24	2.33	2.35	2.38	2.35	4.88	4.53	4.21	4.54
25	2.33	2.33	2.35	2.34	4.71	4.93	4.48	4.71
26	2.34	2.33	2.32	2.33	4.82	4.84	5.02	4.89
27	2.38	2.33	2.36	2.36	4.24	4.70	4.12	4.35
28	2.36	2.35	2.36	2.36	4.40	4.32	4.22	4.31
29	2.34	2.33	2.36	2.34	4.84	4.75	4.46	4.68
30	2.35	2.37	2.38	2.37	4.49	4.18	3.90	4.19
31	2.39	2.36	2.37	2.37	4.86	5.25	5.07	5.06
32	2.39	2.37	2.39	2.38	4.47	4.93	4.55	4.52
33	2.40	2.40	2.43	2.41	4.40	4.37	3.93	4.23
34	2.42	2.38	2.44	2.41	4.48	4.75	4.03	4.42
35	2.42	2.41	2.41	2.41	4.17	4.24	4.27	4.23
36	2.41	2.40	2.42	2.41	4.41	4.31	4.05	4.26
37	2.39	2.36	2.38	2.38	4.99	5.32	4.98	5.10
38	2.40	2.37	2.39	2.39	4.41	5.04	4.58	4.68
39	2.38	2.39	2.37	2.38	4.94	4.54	4.86	4.78
40	2.42	2.42	2.41	2.42	4.32	4.19	4.38	4.30
41	2.43	2.42	2.40	2.42	4.16	4.05	4.38	4.20
42	2.44	2.43	2.47	2.45	3.92	4.06	3.58	3.85

TABLE 7.—*Specific gravity and absorption of concrete slabs*—Con.

TABLE 7.—*Specific gravity and absorption of concrete slabs*—Con.

Section no.	Specific gravity of slab no.				Absorption of slab no.			
	1	3	5	Average	1	3	5	Average
					Percent	*Percent*	*Percent*	*Percent*
43	2.41	2.40	2.44	2.42	4.48	4.52	4.26	4.42
44	2.42	2.39	2.39	2.40	4.38	4.50	4.62	4.50
45	2.42	2.39	2.41	2.41	4.25	4.62	4.31	4.39
46	2.42	2.40	2.41	2.41	4.12	4.60	4.29	4.34
47	2.41	2.42	2.42	2.42	4.18	4.24	4.11	4.18
48	2.41	2.40	2.44	2.42	4.42	4.27	4.15	4.28
49	2.42	2.41	2.42	2.42	4.16	4.47	4.11	4.25
50	2.36	2.37	2.37	2.37	5.75	5.47	5.36	5.53
51	2.39	2.38	[1] 2.36	2.38	5.09	5.17	[1] 5.72	5.33
52	2.40	2.39	2.41	2.40	4.70	5.16	4.81	4.89
53	2.40	2.40	2.38	2.39	4.98	4.50	5.22	4.90
54	2.41	2.39	2.40	2.40	4.70	4.97	4.63	4.77
55	2.43	2.37	2.41	2.40	4.28	5.44	5.08	4.93
56	2.41	2.39	2.43	2.41	5.01	4.97	4.53	4.84
57	2.32	[1] 2.33	2.34	2.33	5.13	[1] 4.94	4.76	4.94
58	2.33	2.33	2.34	2.33	4.92	5.09	4.35	4.79
59	2.33	2.34	2.35	2.34	4.65	4.69	4.44	4.59
60	2.34	2.33	2.36	2.34	4.87	5.08	4.56	4.84
61	2.35	2.33	2.34	2.34	4.44	4.59	4.75	4.59
62	2.35	2.35	2.38	2.36	4.58	4.54	4.43	4.52
63	2.33	2.32	2.35	2.33	4.90	4.82	4.66	4.79
64	2.34	2.34	2.32	2.33	4.64	5.01	5.11	4.92
65	2.31	2.30	2.34	2.32	5.44	5.39	4.43	5.09
66	2.34	2.33	2.34	2.34	4.56	4.85	4.26	4.56
67	2.35	2.34	2.35	2.35	4.74	4.98	4.57	4.76
68	2.32	2.32	2.36	2.33	5.40	5.25	4.66	5.10
69	2.34	2.33	2.35	2.34	4.99	4.94	5.12	5.02
70	2.36	2.35	2.35	2.35	4.38	4.47	4.72	4.52
71	2.33	2.32	2.31	2.32	5.05	4.88	5.36	5.10
72	2.36	2.30	2.34	2.33	4.58	4.99	4.66	4.74
73	2.34	2.34	2.36	2.35	4.67	4.40	4.12	4.40
74	2.32	2.33	2.34	2.33	4.87	4.88	4.90	4.88
75	2.34	2.34	2.37	2.35	4.63	4.43	3.98	4.35
76	2.36	2.34	2.35	2.35	4.18	4.41	4.35	4.31
77	2.32	2.32	2.33	2.32	4.98	5.10	4.92	5.00
78	2.33	2.32	2.33	2.33	5.07	4.87	4.78	4.91
79	2.31	2.32	2.32	2.32	4.95	4.66	4.82	4.81
80	2.33	2.34	2.33	2.33	4.92	4.87	5.00	4.93
81	2.33	2.33	2.37	2.34	4.91	4.81	4.30	4.67
82	2.34	2.33	2.36	2.34	4.58	4.73	3.97	4.43
83	2.34	2.34	2.31	2.33	4.70	4.63	5.19	4.84
84	2.32	2.34	2.32	2.33	4.20	4.05	5.13	4.46
85	2.31	2.32	2.33	2.32	4.93	4.71	4.61	4.75
86	2.36	2.34	2.33	2.34	4.09	4.23	4.66	4.33
87	2.34	2.33	2.33	2.33	4.18	4.59	4.72	4.50
88	2.36	2.32	2.34	2.34	4.05	4.68	4.27	4.33
89	2.35	[2] 2.36	2.36	2.36	5.64	[2] 5.45	5.39	5.49
90	2.36	2.35	2.37	2.36	5.46	5.68	5.24	5.46
91	2.39	2.34	2.38	2.37	4.98	5.86	5.22	5.35
92	2.39	2.38	2.40	2.39	4.87	5.17	4.89	4.98
93	2.41	2.37	2.40	2.39	4.80	5.50	4.78	5.03
94	2.40	2.38	[1] 2.37	2.38	4.97	5.34	[1] 5.51	5.27
95	2.32	2.36	2.36	2.35	6.09	5.78	5.09	5.65
96	2.34	2.36	2.38	2.36	5.86	5.21	5.27	5.45
97	2.37	2.36	2.36	2.36	5.12	5.35	5.47	5.31
98	2.37	2.39	2.36	2.37	5.49	4.84	5.34	5.22
99	2.40	2.37	2.37	2.38	4.73	5.39	5.38	5.17
100	2.38	2.40	2.41	2.40	5.00	4.99	4.42	4.80
101	2.30	2.31	2.29	2.30	5.42	5.66	5.70	5.59
102	2.32	2.30	2.34	2.32	5.24	5.85	4.88	5.32
103	2.33	2.32	2.30	2.32	5.02	4.95	5.83	5.27
104	2.31	2.31	2.31	2.31	5.37	5.40	5.42	5.40
105	2.30	2.32	2.33	2.32	5.55	5.10	4.80	5.15
106	[2] 2.32	2.33	2.34	2.33	[2] 5.29	5.19	4.91	5.13
107	2.31	2.33	2.38	2.34	5.46	5.23	5.48	5.39
108	2.33	2.32	2.31	2.32	5.01	5.36	5.48	5.28
109	2.32	2.32	2.32	2.32	5.02	5.17	5.36	5.18
110	2.32	2.31	2.34	2.32	5.34	5.57	4.90	5.27
111	2.34	2.31	2.34	2.33	4.97	5.38	5.30	5.22
112	2.34	2.31	2.34	2.33	5.14	5.52	4.89	5.18
113	2.32	2.32	2.30	2.31	5.33	5.22	5.54	5.36
114	[2] 2.32	2.33	2.31	2.32	[2] 5.15	4.79	5.34	5.09
115	2.32	2.32	2.34	2.33	5.35	4.82	4.84	5.00
116	2.34	2.36	2.34	2.35	5.05	4.45	4.90	4.80
117	2.33	2.34	2.34	2.34	4.92	4.76	4.83	4.84
118	2.34	2.36	2.36	2.35	5.03	4.67	4.54	4.75
119	2.33	2.32	2.32	2.32	5.04	5.15	5.15	5.11
120	2.31	2.33	2.32	2.32	5.27	4.72	4.97	4.99
121	2.34	2.31	2.31	2.32	4.72	5.21	4.97	4.97
122	2.34	2.34	2.32	2.33	4.49	4.45	4.86	4.60
123	2.34	2.32	2.34	2.33	4.54	4.77	4.78	4.70
124	2.38	2.35	2.34	2.36	4.07	4.39	4.30	4.25
125	2.33	2.34	2.34	2.34	4.62	4.72	4.40	4.58
126	2.33	2.34	2.35	2.34	4.58	4.28	4.10	4.32
127	2.31	2.30	2.32	2.31	5.35	5.52	4.94	5.27
128	2.33	2.32	2.31	2.32	4.77	4.89	5.25	4.97
129	2.34	2.33	2.33	2.33	4.55	4.72	4.79	4.69
130	2.33	2.34	2.33	2.33	4.74	4.73	4.86	4.78
131	2.35	2.35	2.32	2.34	4.62	4.61	5.08	4.77
132	2.35	2.34	2.36	2.35	4.62	4.57	4.33	4.51
133	2.27	--------	2.30	2.28	5.97	--------	5.65	5.81
134	2.34	2.32	2.30	2.32	4.74	4.74	5.30	4.93
135	2.33	2.33	2.33	2.33	4.87	4.83	4.50	4.73
136	2.32	2.31	2.33	2.32	4.85	4.86	4.87	4.86
137	2.34	2.31	2.32	2.32	4.66	5.09	4.98	4.91
138	2.31	2.33	2.32	2.32	5.07	4.59	5.26	4.97
139	2.35	2.35	2.34	2.35	5.74	5.85	5.91	5.83
140	2.39	2.37	2.34	2.37	4.75	4.99	5.65	5.13
141	2.37	2.39	2.38	2.38	4.90	4.55	5.05	4.83
142	2.38	2.39	2.38	2.38	5.02	4.99	5.15	5.05
143	2.40	2.42	2.41	2.41	4.84	4.55	4.43	4.61
144	2.39	2.38	2.40	2.39	4.94	5.19	4.93	5.02
145	2.36	2.36	2.36	2.36	5.34	5.37	5.43	5.38
146	2.36	2.37	2.37	2.37	5.22	5.17	5.10	5.16
147	2.38	2.36	2.37	2.37	5.37	5.66	5.12	5.38
148	2.37	2.38	2.38	2.38	5.23	5.30	5.52	5.35
149	2.41	2.36	2.36	2.38	5.04	5.38	5.76	5.39
150	2.42	2.37	2.40	2.40	4.49	5.35	5.02	4.95
151	2.34	2.38	2.37	2.36	5.79	5.14	5.29	5.41
152	2.35	2.36	2.36	2.36	5.23	5.26	5.27	5.25
153	2.36	2.36	2.39	2.37	4.93	5.18	4.64	4.92
154	2.39	2.35	2.40	2.38	4.94	5.62	4.79	5.12
155	2.40	2.41	2.39	2.40	4.72	5.13	4.98	4.94
156	2.38	2.35	2.38	2.37	5.16	5.55	5.01	5.24
157	2.35	2.35	2.35	2.35	5.42	5.25	5.31	5.33
158	2.38	2.36	2.37	2.37	4.75	5.57	4.73	5.02
159	2.39	2.36	2.37	2.37	4.75	5.01	4.83	4.86
160	2.37	2.36	2.38	2.37	5.13	5.27	4.83	5.08
161	2.36	2.37	2.39	2.37	5.33	5.15	4.90	5.13
162	2.40	2.37	2.38	2.38	4.60	5.15	4.96	4.90
163	2.35	2.38	2.35	2.36	5.39	4.62	5.65	5.22
164	2.38	2.38	2.36	2.37	4.87	5.11	5.20	5.06
165	2.37	2.38	2.39	2.38	5.14	4.85	4.71	4.90
166	2.41	2.38	2.38	2.39	4.62	5.08	5.27	4.99
167	2.37	2.38	2.39	2.38	5.25	4.75	4.66	4.89
168	2.41	2.38	2.41	2.40	4.72	5.05	4.63	4.80
169	2.40	2.39	2.40	2.40	4.53	4.75	4.88	4.72
170	2.34	2.37	2.36	2.36	5.81	5.23	5.34	5.46
171	2.37	2.37	2.37	2.37	5.31	5.26	5.05	5.21
172	2.38	2.36	2.40	2.38	5.10	5.43	4.90	5.14
173	2.41	2.38	2.43	2.41	4.58	4.89	4.25	4.57
174	2.38	2.42	2.38	2.39	4.98	4.20	5.10	4.76
175	2.40	2.39	2.42	2.40	4.78	4.95	4.48	4.74
176	2.40	2.40	2.40	2.40	4.62	4.77	4.35	4.58
177	2.36	2.37	2.35	2.36	5.35	5.08	5.54	5.32
178	2.40	2.35	[1] 2.38	2.38	4.86	5.34	[1] 5.05	5.08
179	2.39	2.38	2.38	2.38	4.79	4.98	4.88	4.88
180	2.39	2.39	2.40	2.39	5.00	4.87	5.08	4.98
181	2.41	2.38	2.42	2.40	4.77	5.21	4.55	4.84
182	2.42	2.42	2.42	2.42	4.64	4.52	4.41	4.52
183	2.31	2.32	2.32	2.32	5.45	5.15	5.06	5.22
184	[2] 2.33	2.33	2.32	2.33	[2] 4.93	4.89	5.16	4.99
185	2.34	2.33	2.34	2.34	4.43	4.89	4.74	4.69
186	2.35	2.32	2.35	2.34	4.49	4.97	4.65	4.70
187	2.31	2.31	2.34	2.32	4.94	5.18	4.68	4.93
188	2.36	2.34	2.35	2.35	4.51	4.67	4.30	4.49
189	2.37	2.34	2.34	2.35	4.20	4.55	4.57	4.44
190	2.28	2.32	2.28	2.29	5.96	5.01	5.84	5.60
191	2.31	2.32	2.32	2.32	5.26	5.35	5.29	5.30
192	2.31	2.30	2.32	2.31	5.06	5.21	5.04	5.10
193	2.33	2.31	2.33	2.32	4.80	5.24	4.96	5.00
194	2.33	2.32	2.32	2.32	4.95	5.18	4.95	5.03
195	2.34	2.33	2.33	2.33	4.82	5.09	4.90	4.94
196	2.34	2.34	2.33	2.34	4.87	4.76	4.85	4.83
197	2.29	2.32	2.30	2.30	5.87	5.48	5.56	5.64
198	2.30	2.30	2.30	2.30	5.45	5.60	5.59	5.55
199	2.28	2.30	2.31	2.30	5.71	5.48	5.60	5.60
200	2.31	2.31	2.33	2.32	5.43	5.56	5.11	5.37
201	2.32	2.34	2.33	2.33	5.31	5.13	5.31	5.25
202	2.34	2.32	2.34	2.33	4.63	5.23	4.77	4.88
203	2.29	2.32	2.27	2.29	5.63	5.40	6.36	5.80
204	[2] 2.30	2.30	2.29	2.30	[2] 5.68	5.69	5.78	5.72
205	2.30	2.28	2.29	2.29	5.39	6.10	6.08	5.86
206	2.32	2.31	2.30	2.31	5.33	5.37	5.48	5.39
207	2.32	2.31	2.31	2.31	5.38	5.73	5.19	5.43
208	2.33	2.30	2.32	2.32	5.28	5.83	5.25	5.45
209	2.29	2.31	2.29	2.30	5.88	4.82	5.41	5.37
210	2.31	2.33	2.29	2.31	5.27	4.26	5.35	4.96
211	2.32	2.31	2.32	2.32	5.01	5.53	5.27	5.27
212	2.33	2.30	2.33	2.32	4.74	5.69	4.50	4.98
213	2.34	2.32	2.33	2.33	4.91	5.30	4.55	4.92
214	2.36	2.33	2.36	2.35	3.97	5.04	4.67	4.56
215	2.30	2.32	2.30	2.31	5.95	4.85	5.25	5.35
216	[2] 2.31	2.30	2.32	2.31	[2] 5.42	4.84	5.28	5.18
217	2.33	2.31	2.34	2.33	4.49	5.12	4.28	4.63
218	2.32	2.31	2.30	2.31	5.13	5.39	5.55	5.36
219	2.34	2.32	2.33	2.33	4.33	5.15	4.55	4.68
220	2.31	2.33	2.32	2.32	4.76	5.14	4.58	4.83
221	2.31	2.29	2.30	2.30	5.56	5.90	5.40	5.62
222	2.32	2.30	2.30	2.31	5.03	5.70	5.65	5.46
223	2.33	2.32	2.32	2.32	5.05	5.14	5.22	5.14
224	2.33	2.32	2.33	2.33	5.34	5.18	5.22	5.25
225	2.33	2.31	2.32	2.32	4.93	4.80	5.30	5.01
226	2.33	2.32	2.34	2.33	5.02	5.36	4.66	5.01
227	2.36	2.37	2.35	2.36	5.58	5.58	6.01	5.72
228	2.37	2.37	2.37	2.37	5.12	5.19	5.17	5.16
229	2.39	2.37	2.37	2.38	5.00	5.41	5.38	5.26
230	2.38	2.38	2.38	2.38	5.16	5.08	5.28	5.17
231	2.37	2.39	2.37	2.38	5.51	5.17	5.44	5.37
232	2.39	2.36	2.41	2.39	5.11	5.85	4.94	5.30
233	2.36	2.37	2.37	2.37	5.68	5.55	5.22	5.48
234	2.37	2.37	2.37	2.37	5.48	4.98	5.42	5.29
235	2.35	2.35	2.37	2.36	5.91	5.83	5.18	5.64
236	2.40	2.36	2.40	2.39	5.22	5.72	4.87	5.27
237	2.39	2.36	2.41	2.39	5.27	5.67	4.89	5.28

[1] Value for slab no. 4 used.
[2] Value for slab no. 2 used.

Table 7.—*Specific gravity and absorption of concrete slabs*—Con.

Section no.	Specific gravity of slab no.				Absorption of slab no.			
	1	3	5	Average	1	3	5	Average
					Percent	*Percent*	*Percent*	*Percent*
238	2.39	2.37	2.39	2.38	5.11	5.70	5.26	5.36
239	2.37	2.36	2.34	2.36	5.36	5.66	5.89	5.64
240	2.36	2.37	2.37	2.37	5.63	5.60	5.15	5.46
241	2.39	2.38	2.35	2.37	5.02	5.35	5.84	5.40
242	2.39	2.37	2.39	2.38	5.26	5.65	5.07	5.33
243	2.36	2.39	2.37	2.37	5.33	4.94	5.29	5.19
244	2.43	2.37	2.39	2.40	4.29	5.45	5.12	4.95
245	2.34	2.35	2.33	2.34	6.01	5.98	6.23	6.07
246	2.32	2.34	2.35	2.34	6.11	6.00	5.75	5.95
247	2.34	2.35	2.33	2.34	6.01	5.75	6.16	5.97
248	2.37	2.37	2.36	2.37	5.95	5.38	5.69	5.67
249	2.36	2.36	2.34	2.35	5.73	5.73	6.28	5.91
250	2.37	2.36	2.37	2.37	5.29	5.52	5.30	5.37
251	2.36	2.34	2.37	2.36	5.29	5.79	5.10	5.39
252	2.34	2.34	2.40	2.36	5.35	5.43	4.52	5.10
253	2.34	2.37	2.38	2.36	5.68	4.94	5.01	5.21
254	2.41	2.38	[1] 2.38	2.39	4.85	4.69	[1] 5.03	4.86
255	2.35	2.35	2.35	2.35	5.67	5.66	5.49	5.61
256	2.37	2.34	[1] 2.37	2.36	5.24	5.79	[1] 5.35	5.46
257	2.36	2.36	[1] 2.37	2.36	5.33	5.35	[1] 5.26	5.31
258	[2] 2.36	2.37	[1] 2.40	2.38	[2] 5.08	5.32	[1] 4.83	5.08
259	2.36	2.36	2.35	2.36	5.72	5.62	5.87	5.74
260	2.35	2.37	2.34	2.35	5.72	5.28	5.81	5.60
261	2.36	2.36	2.38	2.37	5.66	5.14	5.14	5.31
262	2.38	2.39	2.37	2.38	5.12	4.83	5.51	5.15
263	2.41	2.38	2.38	2.39	4.35	5.14	5.20	4.90
264	2.43	2.38	2.40	2.40	4.29	5.49	5.13	4.97
265	2.35	2.37	[1] 2.36	2.36	5.50	5.42	[1] 5.33	5.42
266	2.38	2.36	2.36	2.37	5.42	5.70	5.53	5.55
267	2.39	2.35	2.37	2.37	5.00	5.59	5.60	5.40
268	2.39	2.36	2.37	2.37	4.98	5.64	5.29	5.30
269	2.36	2.37	2.41	2.38	5.76	5.44	4.83	5.34
270	2.40	2.37	2.42	2.40	5.18	5.63	4.68	5.16

[1] Value for slab no. 4 used.
[2] Value for slab no. 2 used.

It will be evident from the foregoing that the major comparisons regarding the efficiency of surface vibrating equipment of the types now generally available are furnished by the tests in series B (see table 2). These results will therefore be presented first and the detailed discussion will be followed by a brief discussion of the results for series A and C.

The general effect of vibration on the strength and uniformity of concrete, as revealed by results obtained with machines A and B using both crushed stone and gravel, is shown graphically in figure 6. The average results of tests on 26 sets of 6 or 7 sections each, involving the standard operation of the vibrators, are given in this figure. Standard operation for machine A is defined as two passes of the machine, with both screeds vibrating. For machine B, standard operation is defined as one pass forward and back with pan vibrating, and a second pass made without vibration. The sections selected for study in the various figures can be identified by reference to table 2.

REDUCING SLUMP TO 1 INCH INCREASED HONEYCOMB IN NON-VIBRATED CONCRETE

In figure 6 the upper portion of each of the four blocks shows, for each variation in mix, (1) the relative flexural strength of the test slabs; and (2) the relative crushing strengths of cores drilled from test slabs expressed, in each case, as percentages of the strength of 2½-inch slump concrete finished without vibration. The lower portion of each block shows the corresponding data on uniformity indicated by: (1) The average percentage of variation in flexural strength of the five beams taken from each test slab; and (2) the average percentage of honeycomb in the slabs. Reading from left to right, the data shown in the four blocks indicate (1) the effect of increasing the amount of coarse aggregate in the mix while maintaining the water-cement ratio constant; (2) the effect of the same variation in mix for slabs 10 inches thick; (3) the effect of increasing the amount of both fine and coarse aggregate; and (4) the effect of changing the ratio of fine to coarse aggregate while maintaining the cement content constant.

In addition, there is also shown in each block (1) the relative strength and uniformity of standard-finished concrete having the same proportions as the base mix but with the water content reduced to give about a 1-inch slump; and (2) corresponding data for vibrated concrete of the same mix, consistency, and water content.

It is evident from the preceding discussion that by means of figure 6 a number of comparisons can be made, including:

1. The effect of changing the slump from about 2½ inches to 1 inch by decreasing the water-cement ratio with no change in the method of finishing, that is, without vibration (second panel in each block).

2. The effect of vibrating this 1-inch slump concrete (third panel in each block).

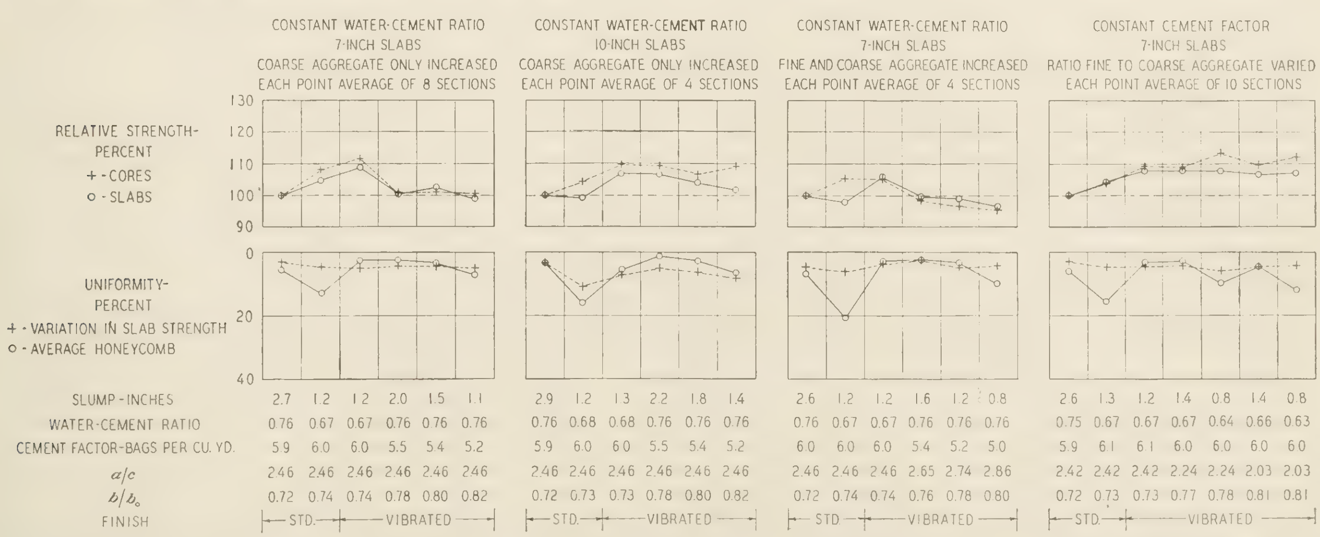
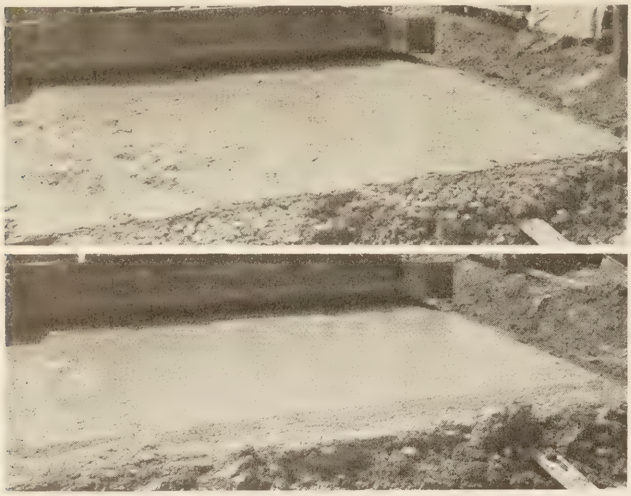


Figure 6.—Effect of Vibration on Strength and Uniformity of Concrete Finished by Standard Operation of Vibrators, Series B. Each Point Is the Average for Sections Containing Crushed Stone and Gravel Finished With Machines A and B.



Appearance of 1-Inch Slump, Base Mix Concrete After First Pass of Finisher. Upper, Nonvibrated Section; Lower, Vibrated Section.

3. The effect of vibrating mixes harsher than the base mix, but having about the same water-cement ratio (fourth, fifth, and sixth panels in blocks 1, 2, and 3).

4. The effect of vibrating mixes harsher than the base mix, but having about the same cement factor (fourth, fifth, sixth, and seventh panels in block 4).

In studying this and subsequent charts, it should be recalled that in virtually all cases five slabs and three cores from each section were tested. Therefore almost every point in the diagrams represents a number of individual test values equal to five times the number of sections in the case of flexure, and three times the number of sections in the case of the cores. Results of 824 flexure tests and 498 compression tests are thus represented in figure 6.

In discussing figure 6, the several comparisons already noted will be considered in the order indicated.

The effect of reducing the slump to 1 inch without vibration is considered first.

In two of the four groups the average flexural strength was increased approximately 5 percent by reducing the slump to about 1 inch with a corresponding decrease in water-cement ratio. In the other two groups, one of which represents tests on the 10-inch sections, a slight decrease in flexural strength is noted. A weighted average value for the 22 sections of 7-inch concrete indicates an average increase in flexural strength of about 3 percent.

The average increase in flexural strength of the corresponding 22 sets of control beams was approximately 7 percent, a value that may be said to represent the normal increase in strength of the concrete when tested in the usual manner, that is, in the form of 7 by 7-inch beams molded in accordance with standard laboratory procedure.

The smaller increase in strength shown by the slabs as compared with the beams probably results from the lack of workability of the 1-inch slump concrete, as placed in the pavement. This has been noted in previous reports.

The lack of workability of the 1-inch slump concrete is also revealed by the high percentage of honeycomb found in the slabs. (See second panels in lower portion of each block and compare also figures 2 and 3.) In every case the tendency to honeycomb was markedly increased by decreasing the slump to 1 inch without vibrating the concrete. This same trend was noted in the earlier work and furnished the justification for the Bureau's requirement that 2-inch slump concrete be used in pavement construction.

Decreasing the slump to 1 inch slightly increased the average variation in slab strength in all three groups of 7-inch slabs and substantially increased the average variation in the 10-inch slabs.

In the matter of crushing strength of the cores, a weighted average for the 22 sections 7 inches thick shows an increase of about 6 percent as the result of reducing the water-cement ratio by 0.09. The average increase in cylinder strength for the same 22 sections was about 14 percent, which is about the amount that would theoretically be expected from a change in the water content of this magnitude.

The reason why the cores did not show a corresponding increase in strength is not definitely known. All were drilled from nonhoneycombed areas and it was expected that they would reflect the effect of changing the water content to about the same extent as the cylinders. However, attention is called to the fact that the cylinders were rodded in accordance with standard laboratory practice and that the standard-finished slabs made of 1-inch slump concrete were probably not adequately consolidated.

EFFECT OF SURFACE VIBRATION EXTENDED ENTIRELY THROUGH SLABS

The effect of vibrating 1-inch slump concrete of the same proportions as the base mix is considered next.

These values are shown in the third panel of each block in figure 6. Increase in flexural strength of vibrated concrete as compared with the base mix ranged from about 7 to 9 percent, with a weighted average for the twenty-two 7-inch sections of about 8 percent, or 5 percent higher than the nonvibrated, 1-inch slump concrete. The 10-inch slabs showed about the same average increase in strength as compared to the base mix. However, in this group the strength of the 1-inch slump, nonvibrated concrete was slightly less than that of the base mix. It is probable that in the case of the 10-inch slabs the lack of workability of the 1-inch slump concrete resulted in less uniform concrete under the standard method of finishing than in the 7-inch slabs. This is indicated by the relatively high variations in slab strengths shown for the nonvibrated concrete having a 1-inch slump.

The uniformity of concrete in the three groups of 7-inch slabs as revealed by the percentage of honeycomb was improved somewhat by vibration. In each of these groups, the average amount of honeycomb was slightly less than that shown by the base mix. In the case of the 10-inch slabs it was slightly greater. However, in all cases the amount of honeycomb in the 1-inch slump, vibrated concrete was very much less than in the similar mix finished by the usual method. (Compare also figs. 3 and 4.)

The comparatively large amount of honeycomb found in the 1-inch slump, vibrated concrete in the group of 10-inch slabs may indicate that, for this depth of section, a slump somewhat greater than 1 inch would probably prove more satisfactory when vibration is to be used. This is indicated by the improvement in uniformity shown in the vibrated sections in which the average slump was 2.2 inches (panel 4). The very substantial reduction in the tendency of the 1-inch slump concrete to honeycomb on the bottom when vibrated seems to indicate definitely that the effect of the surface vibration of the concrete extended entirely through the slabs. This has been a disputed point ever since vibration was introduced.

Except for the 10-inch slabs, the average variation in slab strength was about the same as found for the base mix. The 10-inch slabs showed considerably less uniform results for the drier mixes.

The crushing strengths of cores from the twenty-two 7-inch sections of 1-inch slump, vibrated concrete averaged about 9 percent higher than for the base mix and about 3 percent higher than for the 1-inch slump, nonvibrated concrete. The crushing strengths of cores from the 10-inch sections showed about the same relative improvement. The increase in strength over the 1-inch slump, nonvibrated concrete was probably caused by vibration. This is indicated by the fact that the control cylinders, which were not vibrated, had almost exactly the same average crushing strength as the control cylinders representing nonvibrated concrete of the same consistency.

Further evidence of the undesirability of placing 1-inch slump concrete by the usual methods of finishing is afforded by the following comparison. The average percentage of variation in slab strength shown in figure 6 indicates the average uniformity of the concrete within a given test section. Uniformity may also be studied by comparing the average variation from the average flexural strength for the 22 sections of 7-inch concrete containing the base mix with similar variations for the corresponding 22 sections containing the 1-inch slump concrete, both nonvibrated and vibrated. Although these sections were laid on different days, they were laid in such a way as to eliminate the effect on these comparisons of variations in curing conditions.

The average percentage of variation in flexural strength for the 22 sections containing 2½-inch slump concrete was 2.9 percent, compared with 4.4 percent for the corresponding 22 sections containing the 1-inch slump concrete and 2.6 for the 22 vibrated sections of 1-inch slump concrete. These values are not shown in the figures or in table 4, but were obtained from data in table 6 for the sections represented in figure 6. It is interesting to note that the average day-to-day variation in flexural strength of the base mix (2.9 percent) was about the same as the average variation (3.2 percent) in the strength of the five slabs composing a given section. This would indicate that variations in curing and other conditions incidental to the average job do not cause greater variations in the strength of sections laid on different days than do factors such as depositing and spreading, which affect the uniformity of the concrete within a given section.

PRACTICAL APPLICATION OF FINDINGS

Depending upon the objective sought, existing specifications for pavement concrete may be modified to utilize vibration to advantage in either of the following ways:

1. By providing for adjustment of proportions to give a slump of approximately 1 inch with the same net water-cement ratio as is used in standard construction.

2. By providing for adjustment of proportions to give the same cement content as is used in standard construction but with the slump specified at 1 inch instead of 2½ inches.

In either case the specification should be worded so as to permit the engineer to vary the relative proportions of fine and coarse aggregate to produce the best results, depending upon the type and grading of the aggregates used and the type of finishing equipment employed.

VIBRATING ENABLED REDUCTION IN CEMENT CONTENT WITHOUT SACRIFICING STRENGTH

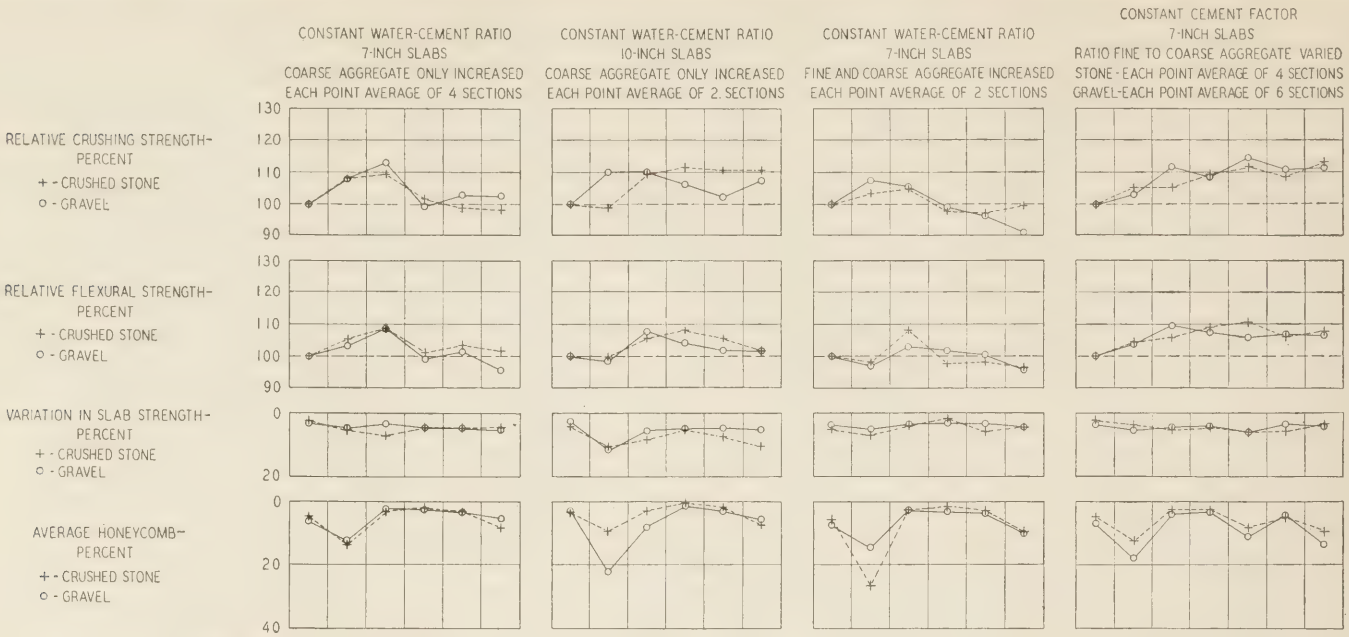
The effect of vibrating mixes harsher than the base mix is considered next. Mixes having a constant water-cement ratio and in which only the quantity of coarse aggregate was increased are discussed first. Data for the 7-inch sections are shown in the fourth, fifth, and sixth panels of the first block of figure 6.

In these sections the water-cement ratio used in the base mix was maintained constant, the slump being reduced by the addition of coarse aggregate to give average values of b/b_0 of 0.78, 0.80, and 0.82 as compared with 0.72 for the base mix. It will be observed that the average flexural and compressive strengths are both almost exactly the same as for nonvibrated base-mix concrete. The uniformity of the concrete as measured by the percentage of honeycomb was also about the same, although there was a tendency for the amount of honeycomb to increase as the mix became harsher. Uniformity as measured by variation in slab strength was about the same for all conditions in this group.

Corresponding values for the 10-inch slabs are shown in the second block of figure 6. In this case all of the harsher mixes when vibrated showed higher strengths both in flexure and compression than the base mix, although the flexural strength decreased as the percentage of coarse aggregate was increased. The uniformity of the harsher mixes as measured by honeycomb also compared favorably with the standard, although a decrease in uniformity was found as the amount of coarse aggregate was increased beyond a certain point. Uniformity as indicated by variations in slab strength was somewhat less than for the corresponding 7-inch sections.

It should be noted that in both the 7-inch and the 10-inch slabs the leanest and harshest mixes gave as high strengths as the base mix even though the cement factor averaged three-fourths of a sack per cubic yard less. The slump averaged slightly more than 1 inch and the water-cement ratio and sand-cement ratio were the same as for the base mix, that is 0.76 and 2.46, respectively.

Mixes having a constant water-cement ratio and in which both fine and coarse aggregate were increased are discussed next. Results are shown for the 7-inch slabs in the third block in figure 6. The results do not differ materially from those for the group in which only the amount of coarse aggregate was varied, although there tended to be a slightly greater reduction in



SLUMP - INCHES	CRUSHED STONE	2.7	1.2	1.2	2.0	1.5	1.1	3.0	1.4	1.4	2.4	1.9	1.4	2.8	1.2	1.1	1.9	1.4	0.9	2.7	1.4	1.2	1.4	0.8	1.4	0.8
	GRAVEL	2.6	1.3	1.2	2.0	1.5	1.2	2.8	1.1	1.1	2.0	1.8	1.4	2.4	1.2	1.2	1.2	0.9	0.8	2.6	1.2	1.2	1.4	0.8	1.4	0.8
WATER-CEMENT RATIO	CRUSHED STONE	0.79	0.69	0.69	0.79	0.79	0.79	0.80	0.72	0.72	0.80	0.80	0.80	0.78	0.67	0.67	0.78	0.78	0.78	0.77	0.70	0.70	0.70	0.66	0.70	0.66
	GRAVEL	0.72	0.65	0.65	0.72	0.72	0.72	0.72	0.64	0.64	0.72	0.72	0.72	0.74	0.66	0.66	0.74	0.74	0.74	0.74	0.65	0.65	0.66	0.62	0.64	0.61
CEMENT FACTOR-BAGS PER CU. YD.	CRUSHED STONE	5.9	6.0	6.0	5.5	5.4	5.2	5.8	6.0	6.0	5.6	5.4	5.2	6.0	6.0	6.0	5.4	5.2	5.0	5.9	6.0	6.0	6.0	6.0	6.0	6.0
	GRAVEL	6.0	6.0	6.0	5.6	5.4	5.2	6.0	6.1	6.1	5.5	5.4	5.2	6.0	6.0	6.0	5.4	5.2	5.0	5.9	6.1	6.1	6.0	6.0	6.0	6.0
a/c	CRUSHED STONE	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.67	2.86	2.94	3.04	2.67	2.67	2.67	2.47	2.47	2.27	2.27
	GRAVEL	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.24	2.45	2.55	2.67	2.24	2.24	2.24	2.08	2.08	1.88	1.88
b/b_0	CRUSHED STONE	0.72	0.74	0.74	0.78	0.81	0.83	0.72	0.73	0.73	0.78	0.80	0.82	0.72	0.74	0.74	0.77	0.79	0.80	0.73	0.74	0.74	0.78	0.78	0.82	0.82
	GRAVEL	0.72	0.73	0.73	0.77	0.80	0.82	0.72	0.73	0.73	0.77	0.80	0.82	0.72	0.72	0.72	0.75	0.77	0.78	0.72	0.73	0.73	0.76	0.77	0.80	0.80
FINISH		STD.	VIBRATED					STD.	VIBRATED					STD.	VIBRATED					STD.	VIBRATED					

Figure 7.—Effect of Type of Coarse Aggregate on Strength and Uniformity of Concrete Finished by Standard Operation of Vibrators, Series B. Each Point Is the Average for Sections Finished With Machines A and B.

strength as the quantity of aggregate was increased. The percentage of honeycomb was substantially increased for the sections made of concrete having less than 1-inch slump, indicating that this slump is about the lowest that should be used with the type of equipment employed in these tests. This holds true even where the cement content was maintained constant, as will be noted by referring to the fifth and seventh panels in the fourth group, where the slump was also less than 1 inch.

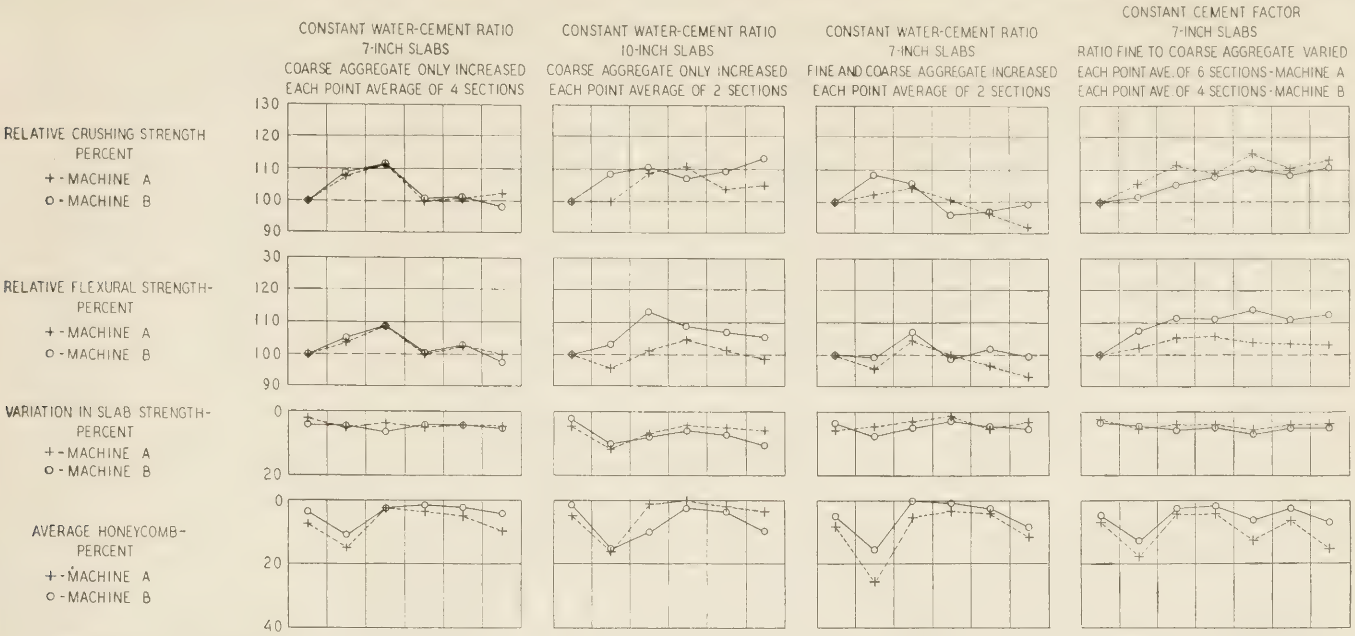
It will be noted that the harshest mix in group 3 contained somewhat less cement and had less slump than the corresponding sections in groups 1 and 2. This resulted from the increased sand content. The results seem to indicate that for concrete vibrated with equipment of the type used in these tests the slump should not be less than 1 inch and that the cement factor should not be reduced by more than three-fourths sack per cubic yard. The results also show that nothing is gained either in strength or uniformity by increasing the sand content.

Mixes having a constant cement factor and in which the ratio of fine to coarse aggregate was varied are discussed next. It will be observed that the strengths of all the vibrated sections were greater than that of the base mix. This applies to both flexure and compression. The flexural strength remained virtually the same but the crushing strength increased in the two cases where the slump was reduced to 0.8 inch by lowering the water-cement ratios to 0.64 and 0.63, the lowest average values used in the test. It would appear from these data that the flexural strength of concrete is not affected appreciably by varying the ratio of fine to coarse aggregate within the limits used in these tests. However, the tendency to honeycomb is increased by drying the mix to less than 1-inch slump.

The comparatively high crushing strengths of the sections containing the 0.8-inch slump concrete is explained by the fact that the cores were drilled from nonhoneycombed areas. Under these conditions the strengths paralleled the reduction in water-cement ratio. These data illustrate the danger of drawing conclusions regarding the quality of paving concrete solely from the results of core tests.

VIBRATED CONCRETE HAD SLIGHTLY GREATER SPECIFIC GRAVITY AND LESS ABSORPTION

In figure 7 the data shown in figure 6 have been plotted to indicate the effect of the type of coarse aggregate on the results. Except for group 4, each point represents just half the number of sections shown in the corresponding panels of figure 6. Comparing relative crushing strengths first, it will be observed that, except for the 10-inch slabs, there was no consistent difference that may be attributed to the coarse aggregate. For the 10-inch slabs, three of the vibrated crushed-stone sections had higher relative strengths than the corresponding gravel sections. There likewise appeared to be no consistent difference in relative flexural strength of 7-inch sections. This does not bear out the conclusion drawn as the result of the work in 1931, where a considerably greater relative increase in flexural strength under vibration was indi-



Group 1 (constant water-cement ratio, 7-inch slabs, coarse aggregate only increased)

SLUMP - INCHES	MACHINE A	2.5	1.2	1.3	1.9	1.4	1.2
	MACHINE B	2.8	1.2	1.1	2.1	1.6	1.1
WATER-CEMENT RATIO	MACHINE A	0.74	0.67	0.67	0.75	0.75	0.75
	MACHINE B	0.77	0.68	0.68	0.77	0.77	0.77
CEMENT FACTOR-BAGS PER CU. YD.	MACHINE A	6.0	6.0	6.0	5.6	5.4	5.2
	MACHINE B	5.9	6.0	6.0	5.5	5.4	5.2
a/c	MACHINE A	2.46	2.46	2.46	2.46	2.46	2.46
	MACHINE B	2.46	2.46	2.46	2.46	2.46	2.46
b/b_o	MACHINE A	0.72	0.74	0.74	0.78	0.80	0.82
	MACHINE B	0.72	0.74	0.74	0.78	0.80	0.82

FINISH: |← STD. →|← VIBRATED →|

Group 2 (constant water-cement ratio, 10-inch slabs, coarse aggregate only increased)

SLUMP - INCHES	MACHINE A	3.1	1.3	1.4	2.4	1.9	1.7
	MACHINE B	2.7	1.2	1.1	2.0	1.8	1.1
WATER-CEMENT RATIO	MACHINE A	0.75	0.68	0.68	0.75	0.75	0.75
	MACHINE B	0.78	0.68	0.68	0.78	0.78	0.78
CEMENT FACTOR-BAGS PER CU. YD.	MACHINE A	6.0	6.0	6.0	5.6	5.4	5.2
	MACHINE B	5.9	6.0	6.0	5.5	5.4	5.2
a/c	MACHINE A	2.46	2.46	2.46	2.46	2.46	2.46
	MACHINE B	2.46	2.46	2.46	2.46	2.46	2.46
b/b_o	MACHINE A	0.72	0.73	0.73	0.78	0.80	0.82
	MACHINE B	0.72	0.73	0.73	0.77	0.80	0.82

FINISH: |← STD. →|← VIBRATED →|

Group 3 (constant water-cement ratio, 7-inch slabs, fine and coarse aggregate increased)

SLUMP - INCHES	MACHINE A	2.6	1.2	1.2	1.7	1.2	0.9
	MACHINE B	2.6	1.2	1.1	1.4	1.0	0.8
WATER-CEMENT RATIO	MACHINE A	0.73	0.64	0.64	0.73	0.73	0.72
	MACHINE B	0.78	0.70	0.70	0.78	0.78	0.80
CEMENT FACTOR-BAGS PER CU. YD.	MACHINE A	6.0	6.1	6.1	5.4	5.2	5.0
	MACHINE B	5.9	6.0	6.0	5.4	5.2	5.0
a/c	MACHINE A	2.46	2.46	2.46	2.65	2.74	2.86
	MACHINE B	2.46	2.46	2.46	2.65	2.74	2.86
b/b_o	MACHINE A	0.72	0.74	0.74	0.76	0.78	0.80
	MACHINE B	0.72	0.73	0.73	0.76	0.78	0.79

FINISH: |← STD. →|← VIBRATED →|

Group 4 (constant cement factor, 7-inch slabs, ratio fine to coarse aggregate varied)

SLUMP - INCHES	MACHINE A	2.6	1.2	1.2	1.4	0.9	1.4	0.8
	MACHINE B	2.6	1.3	1.2	1.5	0.8	1.4	0.8
WATER-CEMENT RATIO	MACHINE A	0.75	0.67	0.67	0.68	0.64	0.67	0.63
	MACHINE B	0.75	0.66	0.66	0.67	0.63	0.66	0.63
CEMENT FACTOR-BAGS PER CU. YD.	MACHINE A	5.9	6.1	6.1	6.0	6.0	6.0	6.0
	MACHINE B	6.0	6.1	6.1	6.0	6.0	6.0	6.0
a/c	MACHINE A	2.39	2.39	2.39	2.21	2.21	2.01	2.01
	MACHINE B	2.46	2.46	2.46	2.28	2.28	2.07	2.07
b/b_o	MACHINE A	0.72	0.73	0.73	0.76	0.78	0.80	0.81
	MACHINE B	0.72	0.74	0.74	0.77	0.78	0.81	0.82

FINISH: |← STD. →|← VIBRATED →|

FIGURE 8.—EFFECT OF TYPE OF FINISHING MACHINE ON STRENGTH AND UNIFORMITY OF CONCRETE FINISHED BY STANDARD OPERATION OF VIBRATORS, SERIES B. EACH POINT IS THE AVERAGE FOR SECTIONS CONTAINING CRUSHED STONE AND GRAVEL.

cated when crushed stone was used as the coarse aggregate.

In the matter of uniformity there is also little to choose between the gravel and crushed-stone aggregates. The greatest difference was in the percentage of honeycomb in the group of 10-inch sections. Here, for some reason, the gravel concrete showed more honeycomb, especially in the sections having 1-inch slump, nonvibrated concrete. However, it should be noted that the average slump of the gravel concrete in these sections was somewhat less than that of the corresponding crushed-stone concrete (see group 2, panel 2, in fig. 7).

Results obtained using machines A and B are compared in figure 8. Considering only crushing strength, there appeared to be no consistent difference in the effectiveness of the two types of vibrating equipment except in group 4, which showed a slight advantage in favor of machine A. On the other hand, the flexural strength results indicated, in two of the four groups, a consistent advantage in favor of machine B. In group 1 there was virtually no difference, while in group 3 there was a slight trend in favor of machine B. On the whole, machine B seemed to give slightly better results as far as increase in flexural strength is concerned. From the standpoint of variation in slab strength (uniformity) the tendency is in the other direction.

There also seemed to be a slight tendency for less honeycomb in concrete finished by machine B, except in the 10-inch slabs, where the trend was reversed. Here again, the difference may result from the slightly lower average slump for the concrete finished with machine B.

In studying figure 8 it should be borne in mind that the values indicate, for each type of equipment, the relative strength obtained when the concrete was vibrated compared with the strength of the concrete finished by the same machine operating without vibration. Differences in quality resulting from variations in the design or operation of the two machines other than the vibrating equipment are not shown. Such comparisons can be made by comparing the average strengths obtained on the base concrete by the two machines. These comparisons, however, are of doubtful value because of the possible effect of variation in curing and other conditions resulting from the fact that the two machines were always used on different days.

The average values for bulk specific gravity and absorption of 6-inch concrete cores drilled from sections in series B are shown in figure 9. The same grouping is used as in figures 6 to 8, inclusive. These values reflect in a general way variations in density of the concrete, as revealed by tests on portions of the slabs free from honeycomb. They bear no relation necessarily to the average density of the slabs as a whole, or to the density of any portion in which honeycombed areas may be included. The differences shown are not of great magnitude in any case, although there seems to be a slight tendency for vibrated sections to have increased specific gravity and lower absorption. It will also be observed that, in general, density increases

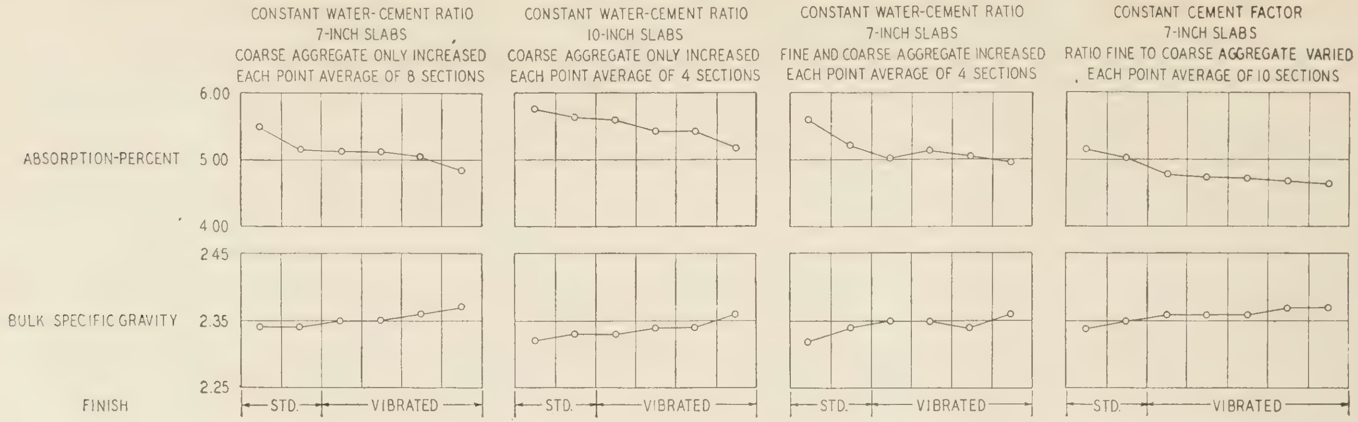
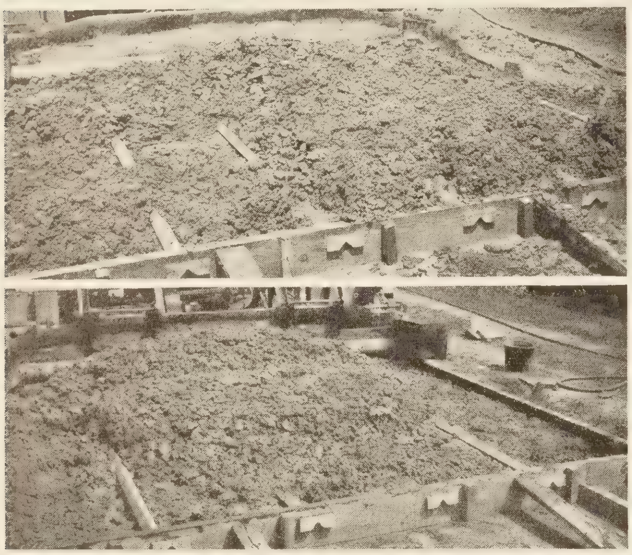


Figure 9.—General Average Values for Absorption and Specific Gravity of Concrete Finished by Standard Operation of Vibrators, Series B. Each Point Is the Average for Sections Containing Crushed Stone and Gravel Finished With Machines A and B. Sections, Reading From Left to Right, Are the Same as in Figure 6.



Appearance of Test Sections After Second Batch Has Been Deposited but Not Spread. Upper, Concrete Deposited by Mixer Discharge Bucket by Method Used in Series A; Lower, Concrete Deposited by Method Used in Series B and C.

as the proportion of coarse aggregate in the concrete increases.

As was indicated in the previous report, it is probable that the harsher concretes, when freshly mixed, contained more air voids than the base mix. The fact that the final densities of these harsh mixtures, as revealed by bulk specific gravity tests on the cores, tended to arrange themselves in about the same order as the theoretical densities (ratio of the sum of the absolute volume of solids to volume of concrete) indicates that the increased densities corresponding to the changes in composition were actually being obtained as the result of the method of compaction used.

WIDE VARIATION IN STRENGTH AND HONEYCOMBING ACROSS SECTION REMEDIED BY VIBRATING

It is evident that one of the benefits derived from the use of vibration in these tests was improvement in the uniformity of the 1-inch slump concrete, obtained by reducing the amount of honeycomb in the slabs. The general relation between honeycomb and slump is shown in figure 10. It will be observed that the tendency of the standard-finished concrete to honeycomb increased rapidly for a slump of about 1 inch, and that a slump of about 2½ inches was required to reduce the honeycomb to 5 percent. On the other hand, the same degree of uniformity was obtained with the vibrated concrete at about 1-inch slump.

Reference to figures 2 to 5, inclusive, which show the distribution of honeycomb on the bottom of sections, illustrates the extent to which honeycombing was concentrated in the outer slabs (numbers 1 and 5) of the test sections.

It will be recalled that in this series the concrete in the two outside slabs was distributed by hand shoveling from the mass as deposited by the mixer discharge bucket. This method of distributing the concrete along the forms and in the corners formed by joints, etc., is practiced to a certain extent on all paving jobs, although efforts are made on well-conducted jobs to eliminate as much of this hand work as possible. Figure 3 illustrates the excessive amount of honeycombing that is apt to form in concrete that is shoveled into place and then finished in the ordinary way. Apparently the surface vibrators were effective in reducing honeycombing because, as shown in figure 6, the average honeycomb in the sections containing the 1-inch slump, vibrated concrete was less even than in the 2½-inch slump, standard-finished concrete and very much less than in the 1-inch slump concrete finished in the usual way.

The effect of the location of the test slab in the section on the strength and amount of honeycomb in the concrete is shown in figure 11. The upper portion of the chart gives for each of the five slabs the average flexural strength of the three groups of twenty-two 7-inch sections shown in figure 6, in which the base proportions were used. The lower portion of figure 11 shows the corresponding percentages of honeycomb in the slabs. Each point is the average of 22 individual values. This figure is of interest particularly in showing how the nonuniform distribution in slabs nos. 1 and 5 in the 1-inch slump, standard-finished concrete affected the strength. In both outer slabs the average strength of the 1-inch slump, standard-finished concrete was less than the strength of the 2½-inch slump, standard-finished concrete. The effect of vibration on honeycomb is also brought out clearly. Note that the average percentage of honeycomb in the 22 no. 1 slabs was reduced from 26 to 3 percent, and in the 22 no. 5 slabs from 31 to 4 percent.

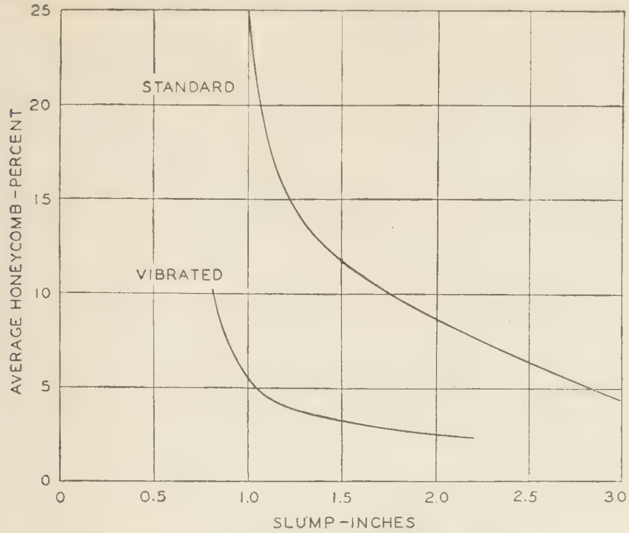


FIGURE 10.—RELATION BETWEEN HONEYCOMB AND SLUMP. SERIES B; 7-INCH SLABS; AVERAGE FOR STONE AND GRAVEL; MACHINES A AND B; STANDARD OPERATION OF VIBRATORS.

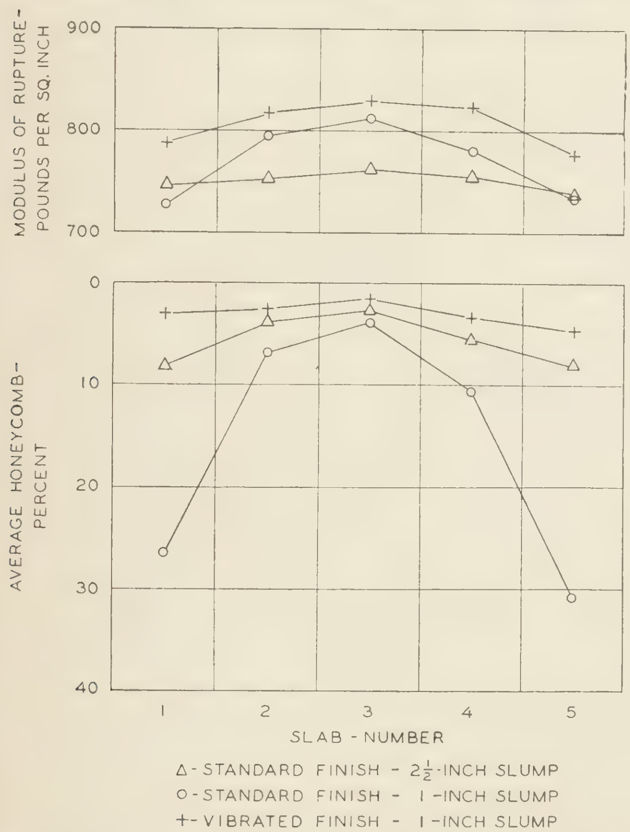


FIGURE 11.—RELATION BETWEEN SLAB STRENGTH AND HONEYCOMB. STANDARD OPERATION OF VIBRATORS; 7-INCH SLABS; SERIES B; AVERAGE FOR MACHINES A AND B; STONE AND GRAVEL.

Also, note that in the case of slab no. 3 the nonvibrated, 1-inch slump concrete showed an average strength about 50 pounds per square inch higher than the base mix, 2½-inch slump concrete. Slab no. 3, being directly under the bucket when dumped, is probably in the most favorable location as regards the effect of consistency upon uniformity. This is indicated by the fact that the average increase in strength of slab no. 3 resulting from the use of 1-inch slump concrete was about

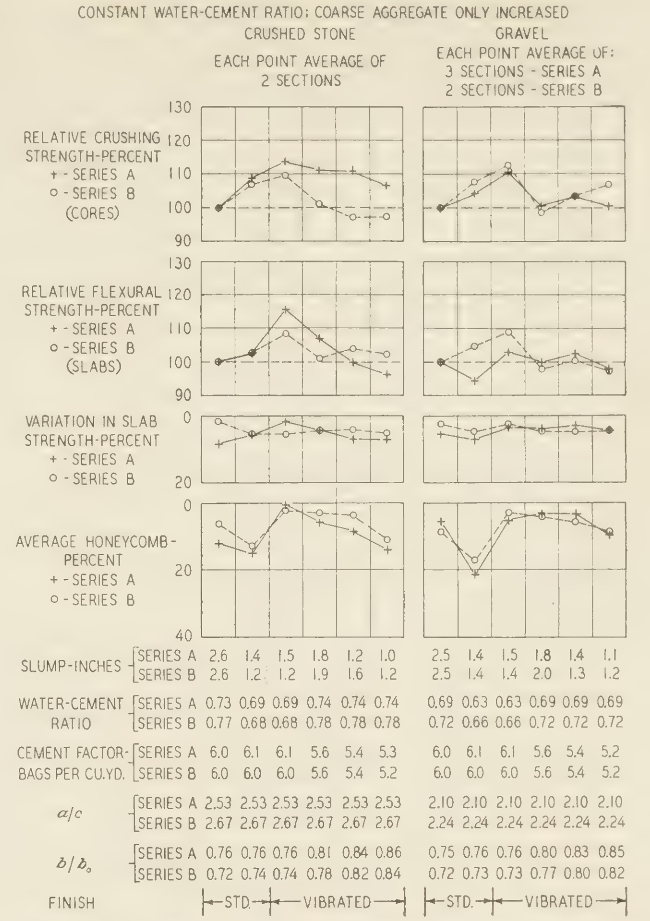


FIGURE 12.—COMPARATIVE SLAB STRENGTH AND UNIFORMITY FOR SERIES A AND B. STANDARD OPERATION OF MACHINE A; 7-INCH SLABS.

7 percent. This is almost exactly the same as the average increase in strength of the corresponding 22 sets of control beams and, as noted, probably represents the normal increase in flexural strength to be expected for these materials caused by a decrease in water content of approximately ¾ gallon per sack of cement.

EFFECTIVENESS OF THE VARIOUS TYPES OF VIBRATING EQUIPMENT COMPARED

As indicated earlier in the report, the first 42 sections, constituting series A, were constructed with a base mix that appeared somewhat undersanded at the time of construction. For this reason it was deemed advisable to repeat in series B that portion of series A involving the standard operation of machine A. This makes possible comparison of the results obtained with machine A in the two series. Data for comparable sections are shown in figure 12. They involve only groups of sections in which the proportions of the base mix were varied by increasing the amount of coarse aggregate.

The two series show, in general, the same trends insofar as the effect of vibration is concerned. The unusually high crushing strengths of the vibrated mixtures in series A, which contained increased quantities of crushed stone, and the relatively low flexural strength of the 1-inch slump, standard-finished gravel concrete, are the principal exceptions. It will be observed that, in general, a somewhat greater uni-

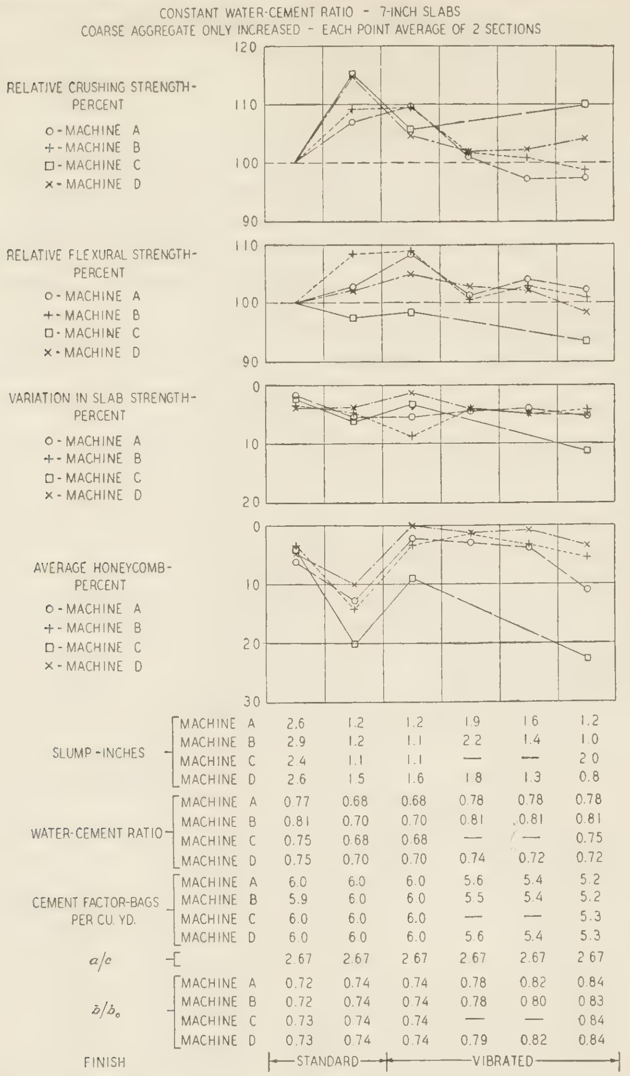


FIGURE 13.—EFFECT OF TYPE OF FINISHING MACHINE ON STRENGTH AND UNIFORMITY OF CONCRETE FINISHED BY STANDARD OPERATION OF VIBRATORS, AND HAVING CRUSHED STONE ONLY. DATA FOR MACHINES A AND B ARE FROM SERIES B; DATA FOR MACHINES C AND D ARE FROM SERIES C.

formity in strength was obtained in series B. This seems reasonable in view of the adjustment made in sand content. However, as shown in the third panel of each block, vibration was about as effective in reducing honeycomb in the base mix in series A as in series B. With increasing quantities of crushed stone the amount of honeycomb increased at a somewhat greater rate in series A. The high percentage of honeycomb, high average variation, and low strength of the harshest crushed-stone mix indicates that the maximum safe value of b/b_0 for vibrated crushed-stone concrete had been exceeded in series A.

In addition to the tests that have been discussed, a few sections were constructed on which the operation of the vibrating equipment was modified to a certain extent. For tests with machine A the modification consisted of operating the finishing machine with only the front screed vibrating. This method was used on four sets of sections—two in series A and two in series B. In the case of machine B the vibrating procedure was changed by vibrating during the forward movement of the machine only. Certain data from these tests have been grouped in table 8.

Referring first to the results obtained with only the front screed of machine A vibrating, and comparing the strength results obtained by vibrating the standard proportion, 1-inch slump concrete with the standard-finished base mix, a slight improvement was noted in two groups of sections only. However, the average percentage of honeycomb was reduced in three of the four groups. The results, in general, indicate that the modified operation was not as efficient as when both screeds were vibrating.

On five groups of sections the operation of machine B was modified so as to omit vibration during the backward movement of the machine. These results are also shown in table 8. In most cases they indicate a slight improvement in the vibrated concrete, but in general the improvement was not as great as was obtained when the vibrating pan was operated during both the forward and backward movement of the machine. Here also vibration seemed to have been generally effective in reducing the amount of honeycomb in the slabs.

TABLE 8.—*Results of special operation of machines A and B; concrete of base proportions only*

MACHINE A.—FRONT SCREED ONLY VIBRATING; 2 PASSES

Section and finish [1]	Consistency, slump	Average modulus of rupture (slabs)	Average crushing strength (cores)	Average honeycomb
	Inches	*Lb. per sq. in.*	*Lb. per sq. in.*	*Percent*
7–S	3.0	685	7,820	5.9
8–S	1.3	688	8,050	5.0
9–V	1.2	711	8,450	.4
13–S	2.4	663	7,360	10.5
14–S	1.1	655	7,930	30.6
15–V	1.0	594	7,540	33.1
215–S	2.4	682	7,820	5.9
216–S	1.0	655	8,000	38.4
217–V	1.0	705	7,800	7.4
233–S	2.4	850	7,430	10.3
234–S	1.0	836	7,860	35.7
235–V	1.0	852	7,520	5.6

MACHINE B.—PAN VIBRATING FORWARD ONLY

Section and finish [1]	Consistency, slump	Average modulus of rupture (slabs)	Average crushing strength (cores)	Average honeycomb
71–S	2.6	674	6,680	8.2
72–S	1.1	720	7,720	13.4
73–V	1.2	698	7,920	4.4
77–S	2.5	703	6,380	5.1
78–S	1.2	698	7,330	3.3
79–V	1.0	712	7,190	3.3
83–S	3.0	665	7,140	2.3
84–S	1.4	734	6,730	4.0
85–V	1.4	701	7,440	4.5
89–S	2.4	794	6,620	0
90–S	1.4	817	6,600	4.5
91–V	1.2	812	6,600	0
151–S	2.7	868	6,280	3.8
152–S	1.1	801	7,120	16.5
153–V	1.2	863	6,530	4.4

[1] Sections 89–91, 151–153, and 233–235 contained crushed stone; balance of sections contained gravel.

The results obtained with crushed-stone concrete, using machines C and D, are shown in figure 13, together with corresponding data for machines A and B. Each point is the average of two sections. This figure compares the four types of surface vibrators that were investigated. Comparing first the relative strength of the virbated concrete of the base proportions (third panel), it will be observed that neither machine C nor machine D gave as good results as machines A and B. This applies to both flexure and compression. Machine D, however, compares favorably with the other type as regards the strength and uniformity of the harsher mixes. Machine C appears to be the least efficient insofar as flexural strength is concerned. Machine C appears to be less efficient than the other types from the standpoint of eliminating honeycomb from the slabs. Machine D was quite effective in reducing honeycomb in the vibrated concrete slabs.

Referring to table 6, it will be noted that almost without exception the strengths of the control beams and control cylinders were lower than the strengths of the corresponding pavement slabs and pavement cores. This parallels previous observations made in connection with similar work. An analysis of test data for the control specimens reveals a number of interesting relationships, among which may be noted the variations in strength obtained on concrete of the same proportions and water content but placed on different days. For instance it will be recalled that the average variation in flexural strength of the twenty-two 7-inch, standard-finished sections in series B that contained 2½-inch slump concrete was 2.9 percent. The average variation for the corresponding 22 control beams was 4.4 percent, indicating that control specimens tend to have wider variations in strength than are to be found in pavement slabs.

The corresponding variations in values for crushing strength were 4.6 percent for the cores and 5.2 percent for the cylinders.

STATUS OF FEDERAL-AID HIGHWAY PROJECTS

AS OF MARCH 31,1937

STATE	APPORTIONMENT 1/	COMPLETED			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	Estimated Total Cost	Federal Aid	Miles	
Alabama	$ 7,872,980	$ 51,600	$ 25,800	9.0	$ 1,374,281	$ 687,130	71.2	$ 339,290	$ 169,640	12.1	$ 6,990,410
Arizona	5,394,661	2,021,783	1,564,817	116.6	1,151,761	1,095,808	47.4	381,341	272,720	15.9	2,461,315
Arkansas	6,463,681				1,613,679	1,612,354	75.8	1,737,375	1,736,146	118.4	3,115,181
California	14,366,891	5,987,362	3,408,467	151.4	8,587,612	4,899,585	225.4	1,982,772	1,005,678	34.6	5,053,161
Colorado	6,911,198	3,974,044	2,113,986	160.1	3,415,669	1,913,613	129.2	784,462	438,256	33.3	2,445,343
Connecticut	2,388,339	771,100	385,412	14.2	705,928	350,556	8.7				1,652,370
Delaware	1,843,750	576,378	280,117	27.5	364,282	181,956	8.5	217,279	108,635	5.7	1,273,042
Florida	5,020,323	1,016,214	502,728	31.5	1,703,255	851,623	57.9	609,970	304,985	7.4	3,360,987
Georgia	9,569,722	1,488,755	703,017	102.9	2,443,984	1,221,977	129.7	932,680	466,340	46.2	7,178,388
Idaho	4,635,991	2,661,103	1,544,662	256.6	1,097,785	656,844	72.7	580,515	347,395	29.3	2,087,090
Illinois	15,564,720	8,342,942	4,155,155	134.5	5,681,179	2,785,823	153.0	4,228,678	2,111,477	110.4	6,512,264
Indiana	9,333,269	5,393,789	2,670,751	179.1	4,201,102	2,099,713	86.5	2,624,393	1,312,119	88.1	3,250,687
Iowa	9,757,950	7,241,804	3,517,926	493.8	3,399,846	1,595,390	107.3	2,921,160	1,273,329	86.2	3,371,305
Kansas	10,005,211	3,231,854	1,610,483	664.5	5,287,970	2,617,534	367.6	4,567,954	2,283,963	182.5	3,493,231
Kentucky	6,961,271	2,255,639	1,102,787	150.7	1,362,578	681,294	28.7	2,003,563	1,001,781	61.4	4,175,409
Louisiana	5,387,420	1,855,513	925,033	66.1	810,147	405,072	28.1	1,210,494	545,330	30.7	3,511,985
Maine	3,299,867	1,919,415	931,686	58.9	888,898	444,449	22.4	921,720	460,860	31.0	1,462,873
Maryland	3,094,808				1,256,417	628,173	19.6	563,067	281,533	8.4	2,185,102
Massachusetts	5,255,300	333,935	166,968	3.1	4,322,180	2,161,090	20.3	487,090	243,545	2.3	2,683,697
Michigan	11,562,296	9,230,185	4,561,003	332.3	4,938,669	2,468,431	123.7	3,357,350	1,678,050	86.7	2,854,812
Minnesota	10,344,485	8,193,397	3,847,653	532.8	2,515,487	1,255,731	133.2	1,777,230	888,615	70.9	4,352,486
Mississippi	6,635,344	4,640	2,320		1,211,700	605,850	79.4	3,565,100	1,781,440	153.4	4,245,734
Missouri	11,479,090	4,104,251	2,043,199	448.9	7,883,065	3,928,253	265.3	2,662,468	1,320,427	113.1	4,187,210
Montana	7,744,061	4,134,820	2,314,535	409.3	2,226,576	1,246,660	147.1	1,222,888	646,873	63.4	3,535,993
Nebraska	7,809,353	3,013,595	1,504,069	182.1	2,616,178	1,313,671	276.7	1,654,074	827,018	217.1	4,164,595
Nevada	4,821,864	1,664,266	1,435,963	272.2	1,674,670	1,446,669	54.4	9,600	8,300	.5	1,930,932
New Hampshire	1,843,750	844,062	406,141	24.8	192,933	96,014	2.3				1,341,595
New Jersey	5,054,295	2,466,551	1,233,124	34.6	2,257,052	1,051,231	24.9	48,350	24,175		2,745,764
New Mexico	6,030,708	3,656,928	2,244,783	300.0	1,686,671	1,025,817	95.3	1,080,108	658,336	71.4	2,101,772
New York	18,565,567	8,074,939	3,976,459	167.7	15,937,284	7,637,642	252.9	1,924,500	647,250	27.4	6,304,216
North Carolina	8,877,837	2,492,655	1,242,861	313.0	3,870,530	1,931,965	262.1	2,558,740	1,099,820	117.7	4,603,191
North Dakota	5,914,683	193,080	103,375	.3	191,740	101,206	.1	487,132	487,040	79.8	5,223,062
Ohio	13,771,548	2,481,216	1,236,370	44.3	6,123,269	2,939,631	64.5	2,748,680	1,349,840	28.6	8,245,707
Oklahoma	8,880,547	2,714,308	1,410,154	93.4	2,427,856	1,273,571	86.0	2,136,901	1,122,921	80.4	5,073,901
Oregon	6,182,079	3,002,674	1,807,515	112.8	3,075,531	1,836,922	129.4	1,224,945	681,092	30.0	1,856,550
Pennsylvania	16,129,804	6,677,091	3,316,059	111.3	8,391,644	4,187,994	120.6	4,015,953	1,937,511	54.7	6,688,241
Rhode Island	1,843,750	213,888	106,944	3.4	678,336	339,168	5.6	190,077	92,864	2.1	1,304,774
South Carolina	5,103,525	576,230	219,400	50.9	4,440,530	1,781,020	278.1	716,752	272,302	68.0	2,830,803
South Dakota	6,162,747	1,385,603	778,010	188.6	127,860	80,869	36.5	1,142,696	628,344	91.7	4,675,525
Tennessee	7,949,380	2,260,730	1,128,235	98.8	1,055,616	527,803	36.2	1,400,508	700,259	53.0	5,593,083
Texas	23,506,431	12,553,750	6,253,927	696.2	9,111,160	4,513,168	616.3	5,019,684	2,478,595	294.6	10,260,742
Utah	4,274,740	2,090,475	1,462,744	138.1	1,126,283	811,541	82.5	131,050	90,226	12.8	1,910,229
Vermont	1,843,750	1,309,726	647,508	62.9	801,645	373,910	23.1	250,299	125,070	9.2	697,262
Virginia	6,887,569	2,834,126	1,414,222	112.8	2,844,932	1,422,463	125.4	1,628,433	814,217	48.8	3,236,667
Washington	5,907,615	3,946,453	2,070,727	155.1	2,040,606	1,070,871	79.5	458,276	230,060	3.7	2,535,957
West Virginia	4,107,201	863,018	431,486	42.3	890,456	445,216	23.9	594,525	297,263	10.9	2,933,237
Wisconsin	9,197,557	3,862,454	1,833,583	160.6	4,250,178	2,070,628	134.0	476,190	237,230	14.1	5,056,115
Wyoming	4,722,322	2,857,375	1,750,138	360.8	1,803,756	1,105,400	180.0	1,246,750	770,480	117.5	1,096,304
Puerto Rico	625,000										625,000
Hawaii	1,843,750	29,953	14,542	.8	783,072	388,545	14.5	111,710	55,520	2.9	1,385,143
TOTALS	368,750,000	146,855,669	76,406,844	8,071.6	147,143,838	76,167,844	5,413.5	70,934,772	36,314,870	2,828.3	179,860,442

1/ Apportionments for Fiscal Years 1936 to 1938, Inclusive.

CURRENT STATUS OF UNITED STATES WORKS PROGRAM HIGHWAY PROJECTS

(AS PROVIDED BY THE EMERGENCY RELIEF APPROPRIATION ACT OF 1935)

AS OF MARCH 31, 1937

STATE	APPORTIONMENT	COMPLETED			UNDER CONSTRUCTION			APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
		Estimated Total Cost	Works Program Funds	Miles	Estimated Total Cost	Works Program Funds	Miles	Estimated Total Cost	Works Program Funds	Miles	
Alabama	$ 4,151,115	$ 3,312,723	$ 3,297,736	109.2	$ 771,036	$ 771,036	29.1				$ 82,342
Arizona	2,569,841	2,554,786	2,197,348	163.0	627,373	330,201	32.9				42,291
Arkansas	3,352,061	2,630,094	2,611,333	278.2	701,359	700,085	80.9				40,643
California	7,747,928	5,778,244	5,603,006	228.4	2,064,739	1,969,697	26.8	$ 267,700	$ 61,380	9.1	113,845
Colorado	3,395,263	1,816,571	1,760,386	98.2	153,510	153,494	7.0				1,481,383
Connecticut	1,418,709	419,092	400,115	4.3	552,984	527,217	10.7	206,152	190,569	5.4	300,808
Delaware	900,310	497,551	476,418	47.0	355,632	276,827	19.6				147,065
Florida	2,597,144	1,592,710	1,588,873	75.1	943,377	943,377	23.9				64,893
Georgia	4,988,967	501,931	491,984	29.4	975,075	975,075	64.9	445,112	445,112	36.3	3,076,796
Idaho	2,222,747	2,222,611	2,132,607	182.9	56,927	56,927	2.7				33,213
Illinois	8,694,009	7,456,674	7,397,521	423.8	1,262,470	1,262,392	47.3				34,096
Indiana	4,941,255	2,865,760	2,714,272	122.5	2,187,703	2,187,703	106.0	37,924	37,924	6.3	1,355
Iowa	4,991,664	3,199,450	3,083,008	368.4	2,028,446	1,850,040	157.0	65,891	49,614	2.9	9,002
Kansas	4,994,975	2,636,707	2,617,489	270.8	2,390,421	2,362,181	104.3	15,305	15,305	.8	
Kentucky	3,726,271	2,677,849	2,645,394	311.0	662,136	662,136	34.0	238,799	238,790	6.7	179,951
Louisiana	2,890,429	1,324,897	1,169,740	95.0	1,693,568	1,549,394	71.2	171,682	157,053	10.0	14,242
Maine	1,676,799	1,286,971	1,279,022	57.6	317,194	317,194	14.3	62,100	62,100	2.1	18,483
Maryland	1,750,738	378,205	376,029	17.6	564,058	564,058	10.9	468,914	369,484	12.6	441,168
Massachusetts	3,262,885	216,783	216,783	2.5	2,684,380	2,331,020	15.9	782,404	409,682	.4	305,400
Michigan	6,301,414	6,233,066	6,006,108	287.9	291,871	246,871	4.8	5,766	4,650		43,785
Minnesota	5,277,145	5,153,857	4,382,805	815.6	1,147,311	743,326	85.5	137,137	120,248	2.3	30,766
Mississippi	3,457,552	2,074,178	2,070,270	154.2	1,351,963	1,350,593	80.5				36,689
Missouri	6,012,652	4,072,175	4,035,972	730.4	2,043,541	1,858,824	46.3	38,755	36,659	1.1	81,197
Montana	3,676,416	3,355,609	3,352,332	185.1	245,028	245,028	10.2	9,222	9,222		69,834
Nebraska	3,870,739	2,422,010	2,372,133	264.7	1,138,567	1,137,063	98.8	120,677	120,677	6.5	240,866
Nevada	2,243,074	1,935,300	1,879,205	89.1	342,430	327,430	13.7	2,738	2,738	.3	33,701
New Hampshire	945,225	614,211	588,225	26.7	218,593	216,295	8.1	71,396	70,636	2.8	70,070
New Jersey	3,129,805	667,446	664,446	14.0	2,310,652	2,297,497	16.9	137,412	128,443	6.1	39,420
New Mexico	2,871,397	2,281,478	2,279,516	179.2	375,715	375,715	13.9	105,829	105,829	8.2	110,337
New York	11,046,377	9,110,008	8,683,859	133.8	2,019,260	2,019,260	34.1	305,778	305,778	2.4	37,480
North Carolina	4,720,173	2,730,571	2,697,876	201.2	1,860,128	1,860,128	81.3	124,940	89,000	8.8	73,169
North Dakota	2,867,245	1,529,156	1,526,315	222.2	952,048	948,613	83.3	144,327	144,271	28.2	248,046
Ohio	7,670,815	3,049,995	2,985,685	138.0	4,162,237	4,114,802	134.0	451,150	448,630	30.5	121,698
Oklahoma	4,580,670	2,878,675	2,842,131	282.7	1,391,183	1,378,524	100.2	205,712	205,652	13.6	154,363
Oregon	3,038,642	2,054,423	2,035,590	149.3	1,199,861	838,427	8.9	116,374	116,374	9.5	48,251
Pennsylvania	9,347,797	1,817,187	1,735,150	90.9	2,401,676	2,343,951	64.2	2,629,144	2,506,895	86.6	2,761,802
Rhode Island	989,208	1,054,850	973,538	18.8	9,520	9,520					6,150
South Carolina	2,702,012	1,236,313	1,167,394	119.0	1,104,867	1,080,086	103.3	242,781	242,561	13.4	211,971
South Dakota	2,976,454	1,952,709	1,951,085	383.0	744,347	744,347	80.5	184,020	184,020	29.8	97,002
Tennessee	4,192,460	2,200,158	2,193,276	92.0	1,260,081	1,260,081	42.5	382,822	382,822	2.9	356,281
Texas	11,989,350	11,693,999	10,730,751	1,066.0	1,295,888	1,136,373	41.0	76,061	60,475	6.0	61,751
Utah	2,067,154	1,621,092	1,472,140	163.5	431,344	399,980	26.2	76,141	76,141	3.4	118,893
Vermont	924,306	831,474	734,053	20.6	219,087	160,687	1.6	19,962	19,830	.9	9,736
Virginia	3,652,667	2,874,432	2,807,876	917.8	577,638	576,978	100.7	80,891	69,370	19.1	198,443
Washington	3,026,161	2,621,613	2,356,635	157.7	775,869	669,526	6.7				
West Virginia	2,231,412	645,820	642,323	30.7	1,652,810	1,529,211	63.8	77,060	57,380	2.9	2,497
Wisconsin	4,823,884	4,913,978	4,344,446	328.1	509,195	368,403	15.1				111,035
Wyoming	2,219,155	1,604,518	1,587,722	121.7	600,269	581,401	29.4				50,032
District of Columbia	949,496	949,496	949,496	8.8							
Hawaii	926,033	549,266	530,091	7.3	369,741	366,432	10.0				29,511
TOTALS	195,000,000	130,098,672	124,637,508	10,284.9	53,995,108	50,975,426	2,264.9	8,508,078	7,545,314	377.9	11,841,752

CURRENT STATUS OF UNITED STATES WORKS PROGRAM GRADE CROSSING PROJECTS

(AS PROVIDED BY THE EMERGENCY RELIEF APPROPRIATION ACT OF 1935)

AS OF MARCH 31, 1937

STATE	APPORTIONMENT	COMPLETED					UNDER CONSTRUCTION					APPROVED FOR CONSTRUCTION					BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS
				NUMBER					NUMBER					NUMBER			
		Estimated Total Cost	Works Program Funds	Grade Crossings Eliminated by Separation or Relocation	Grade Crossing Structures Reconstructed	Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Works Program Funds	Grade Crossings Eliminated by Separation or Relocation	Grade Crossing Structures Reconstructed	Grade Crossings Protected by Signals or Otherwise	Estimated Total Cost	Works Program Funds	Grade Crossings Eliminated by Separation or Relocation	Grade Crossing Structures Reconstructed	Grade Crossings Protected by Signals or Otherwise	
Alabama	$4,034,617	$2,379,256	$2,379,256	33	1	6	$1,457,214	$1,457,214	15			$6,220	$6,220			6	$191,927
Arizona	1,256,099	825,527	821,292	9			348,834	337,389	4								97,418
Arkansas	3,574,060	1,460,695	1,455,772	32	4		1,885,363	1,882,858	23	2	2	189,883	189,613	1		28	45,817
California	7,486,362	5,138,522	4,963,742	29	8		2,291,657	2,223,580	15			95,400	95,400	7			203,639
Colorado	2,631,567	1,234,005	1,206,527	21	1		939,941	939,940	8								485,100
Connecticut	1,712,684	73,479	73,479		1		779,991	758,630	5		1	76,314	76,314		1		804,261
Delaware	418,239	130,000	130,000	1													288,239
Florida	2,827,883	1,587,949	1,585,639	16	5		799,954	799,611	12	1		178,000	178,000	2			264,634
Georgia	4,895,949	30,729	29,237		2		852,574	852,574	18	3		317,428	317,428	7		38	3,696,710
Idaho	1,674,479	904,725	898,260	14	1	3	377,057	376,944	5	1	4	24,368	24,368			14	374,907
Illinois	10,307,184	4,012,232	4,011,270	44	1		5,470,293	5,367,093	28	6		850,600	850,600	4			78,221
Indiana	5,111,096	1,709,724	1,579,346	20	9		3,556,105	3,519,505	22	3	162						12,246
Iowa	5,600,679	2,640,027	2,583,088	65	7	1	2,826,646	2,746,787	40	2		257,634	236,880	2		7	33,924
Kansas	5,246,258	1,459,190	1,458,941	22		3	3,838,540	3,763,697	36	1		6,549	6,549			2	17,071
Kentucky	3,672,387	878,563	878,563	12	2		1,916,291	1,626,559	10	3		534,480	534,480	4	3		632,784
Louisiana	3,213,467						1,718,021	1,718,021	18	2		801,791	757,074	5	2		738,372
Maine	1,426,861	485,563	484,640	12		2	584,695	584,103	8			158,534	158,534	1	1		199,584
Maryland	2,061,751	358,388	358,388	3	3		518,504	518,504	3		19	600,004	577,536	2	2		607,323
Massachusetts	4,210,833	888,240	888,240	7	2		2,144,993	2,144,993	16	2		249,991	249,991	1			927,609
Michigan	6,765,197	3,331,462	3,274,451	34	4		3,454,277	3,454,277	11	4							36,469
Minnesota	5,395,441	2,835,355	2,765,325	59	9	37	2,509,840	2,482,579	26	3	3	58,428	58,428		1	1	89,109
Mississippi	3,241,475	1,040,286	1,040,138	28	3	1	1,550,977	1,550,977	24	1		127,270	127,270	4	1	9	523,090
Missouri	6,142,153	651,049	651,049	12			5,337,317	5,141,073	36	1		367,252	253,300	1		2	96,731
Montana	2,722,327	2,495,057	2,494,551	35	6		178,582	178,582	2								49,194
Nebraska	3,556,441	1,759,812	1,757,577	61	1	2	1,414,900	1,414,900	16	2	4	336,118	336,118	4		18	47,846
Nevada	887,260	690,198	690,198	7	3		211,658	193,432	1			3,630	3,630			5	
New Hampshire	822,484	341,748	341,748	3	3		235,462	235,417	3	1	1	168,326	168,326	2			76,993
New Jersey	3,983,826	760,036	760,036	6	2		2,086,690	2,075,645	13	2		490,706	490,706	2	3		657,440
New Mexico	1,725,286	1,053,490	1,053,475	13	1		673,090	670,400	5								1,410
New York	13,577,189	2,393,473	2,388,673	12	9		9,754,281	9,498,235	28	34		655,900	655,900	1	3		1,034,381
North Carolina	4,823,958	1,417,907	1,417,907	19	9		2,270,126	2,250,575	27	8	111	456,100	456,100	4			699,376
North Dakota	3,207,473	489,481	489,402	16			2,003,740	2,000,183	27	4		335,570	335,570	10			382,318
Ohio	8,439,897	342,256	276,763	2	1		5,435,148	5,277,147	35	5	2	2,054,920	1,897,862	17	1	1	988,124
Oklahoma	5,004,711	1,631,466	1,631,396	31	3		1,868,321	1,868,321	22	4		166,996	166,996	3	1	3	1,337,998
Oregon	2,334,204	878,991	878,452	8	5	2	1,491,605	1,410,005	8	1							45,748
Pennsylvania	11,483,613	1,964,345	1,760,257	26	8		7,501,793	6,993,014	45	8	9	879,478	861,678	4	4		1,868,664
Rhode Island	699,691	624,125	623,059	4	1		61,626	61,626		2							15,006
South Carolina	3,059,956	587,872	579,006	14	2	3	1,402,699	1,392,505	26	8		432,825	432,825	3	1	45	655,620
South Dakota	3,249,086	739,942	739,942	22	1	14	1,496,475	1,496,475	31	4	11	438,165	438,165	10		17	574,504
Tennessee	3,903,979	551,263	551,253	11	1	17	2,248,310	2,248,310	25	2	2	526,470	526,470	6		7	577,947
Texas	10,855,982	4,679,868	4,676,065	79	12	1	5,261,403	5,257,162	50	2	5	510,622	510,616	1		171	412,140
Utah	1,230,763	89,918	88,528	1	1	1	1,107,705	1,107,705	16								34,529
Vermont	729,857	499,386	493,786	7	5	14	227,863	187,700	3	1	2	52,138	48,371		1	4	
Virginia	3,774,287	1,617,449	1,546,584	30	7	6	949,070	910,071	11	9	2	284,562	284,562	9	1	12	1,033,070
Washington	3,095,041	1,048,408	1,043,576	15	6	7	1,791,849	1,791,424	8	5		295,031	260,041		1	2	
West Virginia	2,677,937						1,692,633	1,692,631	20	3	1	269,672	269,672	6		4	715,633
Wisconsin	5,022,683	2,020,579	1,988,506	25	4		2,935,206	2,843,954	12	3							190,223
Wyoming	1,360,841	540,621	540,513	7			651,776	651,775	5								168,553
Dist. of Columbia	410,804	170,643	170,643	2			254,921	226,161	1								14,000
Hawaii	453,703	170,404	170,389	2			351,976	283,314	3								
TOTALS	196,000,000	63,613,714	62,668,928	931	154	120	100,717,992	98,463,577	826	143	341	13,257,375	12,841,593	123	27	396	22,025,902

PUBLICATIONS *of the* BUREAU OF PUBLIC ROADS

Any of the following publications may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C. As his office is not connected with the Department and as the Department does not sell publications, please send no remittance to the United States Department of Agriculture.

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Highway Bond Calculations. 10 cents.

Single copies of the following publications may be obtained from the Bureau of Public Roads upon request. They cannot be purchased from the Superintendent of Documents.

SEPARATE REPRINT FROM THE YEARBOOK

No. 1036Y . . Road Work on Farm Outlets Needs Skill and Right Equipment.

TRANSPORTATION SURVEY REPORTS

Report of a Survey of Transportation on the State Highway System of Ohio (1927).

Report of a Survey of Transportation on the State Highways of Vermont (1927).

Report of a Survey of Transportation on the State Highways of New Hampshire (1927).

Report of a Plan of Highway Improvement in the Regional Area of Cleveland, Ohio (1928).

Report of a Survey of Transportation on the State Highways of Pennsylvania (1928).

Report of a Survey of Traffic on the Federal-Aid Highway Systems of Eleven Western States (1930).

UNIFORM VEHICLE CODE

Act I.—Uniform Motor Vehicle Administration, Registration, Certificate of Title, and Antitheft Act.

Act II.—Uniform Motor Vehicle Operators' and Chauffeurs' License Act.

Act III.—Uniform Motor Vehicle Civil Liability Act.

Act IV.—Uniform Motor Vehicle Safety Responsibility Act.

Act V.—Uniform Act Regulating Traffic on Highways.

Model Traffic Ordinances.

A complete list of the publications of the Bureau of Public Roads, classified according to subject and including the more important articles in PUBLIC ROADS, may be obtained upon request addressed to the U. S. Bureau of Public Roads, Willard Building, Washington, D. C.

CURRENT STATUS OF UNITED STATES PUBLIC WORKS ROAD CONSTRUCTION

AS PROVIDED BY SECTION 204 OF THE NATIONAL INDUSTRIAL RECOVERY ACT (1934 FUNDS) AND BY THE ACT OF JUNE 18, 1934 (1935 FUNDS)

AS OF MARCH 31, 1937

STATE	APPORTIONMENTS		COMPLETED				UNDER CONSTRUCTION				APPROVED FOR CONSTRUCTION			BALANCE OF FUNDS AVAILABLE FOR NEW PROJECTS	
	Sec. 204 of the Act of June 16, 1933 (1934 Fund)	Act of June 18, 1934 (1935 Fund)	Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	Estimated Total Cost	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds	Mileage	1934 Public Works Funds	1935 Public Works Funds
Alabama	$ 8,370,133	$ 4,259,842	$15,671,454	$ 8,301,315	$ 3,813,459	770.8	$ 171,795	$ 55,923	$ 115,872	5.8		$ 285,822	1.5	$ 12,895	$ 44,689
Arizona	5,211,960	2,641,935	8,984,153	5,203,675	2,605,035	543.2	24,073		24,073		$ 5,574	810	.1	2,711	12,017
Arkansas	6,748,335	3,428,049	10,968,973	6,627,424	3,371,441	619.9	130,731	80,459	49,922	6.5	33,944	4,200	10.9	6,508	2,486
California	15,607,354	7,932,206	30,647,428	15,607,354	7,741,183	758.7	115,605		115,553						75,471
Colorado	6,874,530	3,486,006	11,256,388	6,874,530	3,459,042	633.2	6,362		6,360						20,604
Connecticut	2,865,740	1,454,868	4,516,913	2,758,269	1,315,170	74.0	59,618	59,618		.1				47,854	139,697
Delaware	1,819,088	923,395	2,782,833	1,818,804	916,230	130.0								284	7,165
Florida	5,231,834	2,661,343	9,010,010	5,175,534	2,419,763	307.3	289,764	56,300	233,464	2.9					8,116
Georgia	10,091,185	5,113,491	13,270,465	9,193,853	3,203,526	754.4	1,143,612	408,690	734,922	73.4	131,952	166,754	10.8	356,691	1,008,288
Idaho	4,486,249	2,277,486	7,077,041	4,477,339	2,153,743	501.4	85,967		83,807	.1		1,886		8,909	38,050
Illinois	17,570,770	8,921,401	26,441,293	17,393,251	7,957,127	716.7	1,141,513	129,245	885,007	13.3	17,560	7,100	7.5	30,714	72,167
Indiana	10,037,843	5,088,963	15,561,813	9,892,557	4,818,774	482.7	227,844	129,083	98,761	2.4		61,728		16,203	109,700
Iowa	10,055,660	5,118,361	15,581,748	10,055,660	4,920,929	1,222.3	209,734		196,600	5.0					832
Kansas	10,089,604	5,117,675	15,426,562	10,089,600	5,009,852	1,132.3	135,923		99,512	13.2				4	8,311
Kentucky	7,517,359	3,818,311	12,185,269	7,504,603	3,719,464	812.7	69,829		69,829	2.8	10,217	15,467		2,539	13,551
Louisiana	5,828,591	2,963,932	9,145,365	5,763,651	2,712,794	259.5	215,480		215,459	11.5				64,940	35,679
Maine	3,369,917	1,711,586	5,248,303	3,346,497	1,671,457	193.5	43,100	15,000	26,540	1.4				8,420	13,589
Maryland	3,564,527	1,810,058	5,659,409	3,475,617	1,103,886	152.2	68,343		68,343	1.5		285,453	7.3	88,910	352,377
Massachusetts	6,597,100	3,350,474	10,399,518	6,552,734	3,094,281	115.5						91,944	.1	44,367	164,249
Michigan	12,736,227	6,452,568	20,697,260	12,736,227	6,304,754	768.1	96,788		96,788			40,000	.4		11,026
Minnesota	10,656,569	5,425,551	16,208,196	10,510,789	4,850,678	1,641.9	372,262	58,110	268,494	7.2		34,800	.7	87,669	271,579
Mississippi	6,978,675	3,540,227	12,756,603	6,788,308	2,982,044	723.8	655,825	142,960	494,238	21.7	9,360	12,131	.4	38,047	51,814
Missouri	12,180,306	6,173,740	18,180,504	12,088,271	4,995,054	1,441.2	1,125,698		1,121,765	6.3				92,035	56,920
Montana	7,439,748	3,769,734	11,764,351	7,425,476	3,655,874	1,058.4	56,546		56,546					14,272	57,314
Nebraska	7,828,961	3,964,364	12,916,662	7,812,918	3,692,772	1,024.7	251,072		251,072	27.1				16,043	20,520
Nevada	4,545,917	2,302,356	7,068,575	4,545,917	2,271,616	758.8	21,979		21,979			1,650			7,111
New Hampshire	1,909,839	969,462	2,999,744	1,904,951	949,520	78.3	4,169		4,169					4,888	15,773
New Jersey	6,346,039	3,220,879	9,096,652	6,045,652	2,452,166	85.9	1,301,908	204,338	663,430	10.9	15,734	9,212	.2	80,316	96,071
New Mexico	5,792,935	2,941,700	8,898,727	5,749,151	2,910,898	749.9	9,681		9,681			7,047	.2	43,784	14,074
New York	22,330,101	11,327,921	39,513,163	21,861,146	10,475,519	821.9	1,344,462	457,434	687,949	3.4	5,522	112,200		5,999	52,253
North Carolina	9,522,293	4,840,941	14,958,870	9,210,235	4,516,899	1,345.8	553,051	291,910	261,141	21.5				20,147	62,901
North Dakota	5,804,448	2,938,967	8,583,233	5,582,621	2,219,879	2,121.9	253,154	132,456	120,698	21.2	50,040	178,190	29.2	39,332	420,199
Ohio	15,484,592	7,865,012	24,762,040	15,378,758	7,526,175	792.1	281,771	40,500	212,354	4.0	58,056	78,000	4.2	7,278	48,483
Oklahoma	9,216,798	4,685,180	14,741,691	9,214,658	4,430,547	806.6	196,489		196,489	.4		31,465		2,141	26,679
Oregon	6,106,896	3,097,814	9,956,493	6,048,081	2,944,641	468.0	64,223		64,223	.8	55,000	16,694	.7	3,815	72,257
Pennsylvania	18,891,004	9,590,788	28,996,008	18,533,017	8,905,563	1,054.0	534,536	192,542	321,211	5.8	149,635	319,659	10.0	15,809	44,355
Rhode Island	1,998,708	1,014,572	3,150,270	1,998,708	1,012,094	89.1	2,478		2,478						
South Carolina	5,459,165	2,770,954	7,970,188	5,206,684	2,435,279	618.3	370,183	161,850	208,003	9.7	40,000	92,710	9.1	50,631	34,962
South Dakota	6,011,479	3,047,643	9,270,234	5,834,195	2,859,580	1,571.6	229,558	77,600	151,958	29.5	55,660	7,630	7.2	44,024	28,475
Tennessee	8,492,619	4,302,991	13,667,901	8,490,706	4,135,256	492.7	140,180		113,164	3.6		46,727	5.9	1,913	7,845
Texas	24,244,024	12,291,253	37,970,887	24,186,074	11,873,448	2,780.0	206,314	14,797	191,197	2.0		193,334	8.0	43,15[illegible]	33,274
Utah	4,194,708	2,132,691	7,430,826	4,192,008	2,132,691	590.9								2,7[illegible]	
Vermont	1,867,573	948,007	3,166,359	1,867,452	940,847	141.0								121	7,160
Virginia	7,416,757	3,765,387	11,572,376	7,290,407	3,357,346	617.0	319,077	83,691	229,754	31.5	6,735	29,892	1.5	35,924	148,395
Washington	6,115,867	3,106,412	9,397,793	6,112,042	3,026,509	302.7	46,596		46,596			14,823	.3	3,825	18,484
West Virginia	4,474,234	2,280,335	6,464,966	4,342,391	1,782,567	212.8	375,487	54,892	297,549	9.4		66,425	.7	76,951	133,794
Wisconsin	9,724,881	4,941,837	15,443,236	9,724,881	4,888,612	619.7	14,415		14,415			635			38,175
Wyoming	4,501,327	2,287,712	6,903,736	4,451,922	2,235,553	1,037.7	37,731	11,728		2.6	4,770		.3	32,906	52,159
District of Columbia	1,918,469	973,842	2,887,584	1,918,469	968,979	22.3						4,863			
Hawaii	1,871,062	949,778	2,779,059	1,857,812	362,218	51.8	552,762		549,594	4.1		14,000		13,250	23,966
TOTALS	394,000,000	200,000,000	630,009,125	389,022,194	184,102,734	35,069.2	13,557,688	2,859,126	9,680,959	362.6	649,759	2,233,251	117.2	1,468,921	3,983,056

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